

# ANNUAL REPORT 1963

*Lake States  
Forest Experiment Station*

M. B. DICKERMAN, DIRECTOR

EST SERVICE

U. S. DEPARTMENT OF AGRICULTURE



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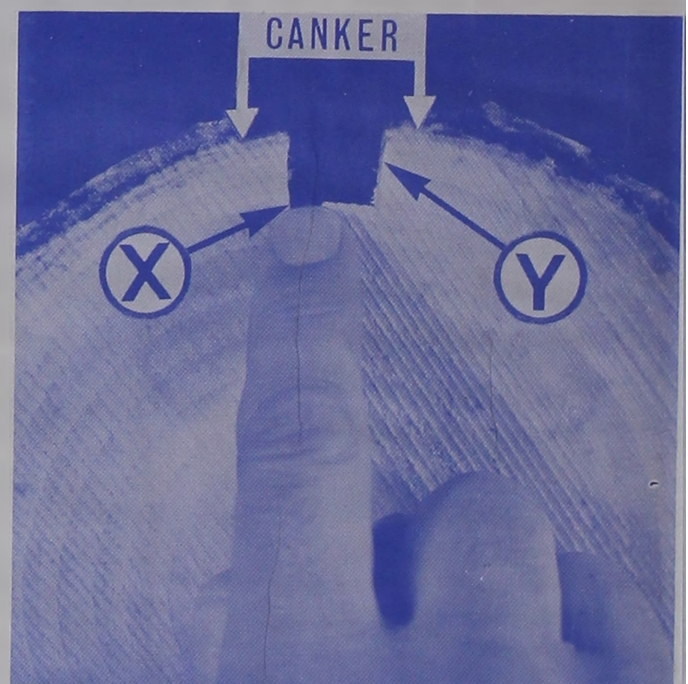
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## DESCRIPTION OF COVER PHOTOS

Front F-506081

Back F-506080

The front and back covers feature two photomicrographs, enlarged 600 times, of cross sections taken from the piece of aspen shown here. Within the larger vessels in both photomicrographs are mycelia of the hypoxylon canker fungus. The cross section on the front cover was two growth rings distant (X) from the canker, while the cross section on the back cover was only one ring away (Y) from the canker — consequently, the mycelium is more dense in the latter. The Station's pathologists are concentrating part of their basic research effort toward learning more about the life cycles of this and other equally destructive forest diseases.





# Highlights of Activities in 1963

The Lake States Forest Experiment Station completed two research efforts of long standing during 1963 with papers published as monographs. "Stem Form Development of Forest Trees," published by *Forest Science Monographs*, was written by Dr. Philip R. Larson, head of the Pioneering Research Unit at the Institute of Forest Genetics, Rhineland, Wis. This paper discusses the four general stem form theories that have been proposed and reviews the literature concerning the biological concept of stem form. "Forest Sites, Bog Processes, and Peatland Types in the Glacial Lake Agassiz Region, Minnesota," published in *Ecological Monographs*, was written by Dr. M. L. Heinselman, research forester at the Station's Northern Conifer Laboratory, Grand Rapids, Minn. Dr. Heinselman's paper reviews the existing literature and describes the origin, development, vegetation, and soils of a vast stretch of nearly continuous peatlands on the site of prehistoric Lake Agassiz.

Another important accomplishment was the publication of "Growth of Four Northern Conifers Under Long and Natural Photoperiods in Florida and Wisconsin." This paper, which appeared in *Forest Science*, was written by Dr. Richard F. Watt of the Lake States Station and Dr. William H. Davis McGregor of Clemson Agricultural College. It indicates that certain northern conifer seedlings, grown under artificially extended photoperiod conditions in Florida's 226-day growing season, could produce field planting stock considerably sooner than is possible in the Lake States. These and 80 other papers written during 1963 by Lake States scientists are significant contributions to the scientific field of forestry in the Lake States and elsewhere.

## PERSONNEL CHANGES AND TRAINING

Several of the past year's events, both sad and happy ones, deserve prominent mention. The Station suffered a tragic loss when Dr. Herbert G. Ewan, head of the Seed and Cone, Aspen, and Shelterbelt Insects Project, lost his life in an automobile accident. Dr. Ewan was an outstanding scientist and a respected member of the Station staff.

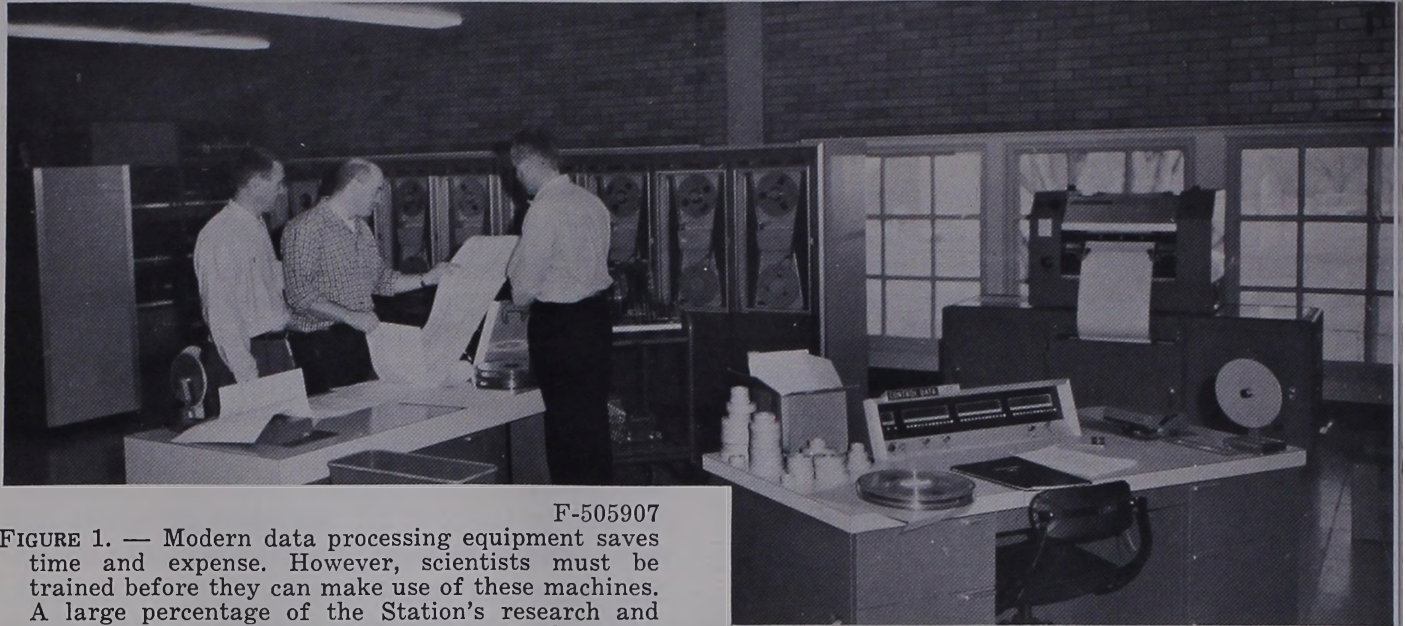
Arlie W. Toole, chief of the Forest Products and Engineering Division, retired in June. Dr. Arne K. Kemp succeeded him. Robert D. McCulley, chief of the Timber Management Division, was transferred to Research Administration in the Washington Office. Z. A. Zasada returned to the Lake States to assume the leadership in that Division. Latest addition to the forest insects research staff is Dr. W. G. Yendol, an insect pathologist. He will be studying the microbial pathogens that may someday be used to control certain economically important forest insects.

Because the Nation's forestry research effort must become deeper and broader if it is to continue to assist the practicing forester, we are always pleased when our scientists strengthen their capabilities through advanced training. Dr. Gerald W. Anderson, head of our Diseases of Aspen Project, earned his doctorate during 1963. We presently have 12 other staff members studying for advanced degrees and many who are taking courses in various specialized fields. About 50 members of our professional staff now have completed special statistical training, mostly at the postgraduate level. This is especially important today because scientists need this background to make best use of automatic data processing (fig. 1). Others are studying such things as the techniques of using radioisotopes, supervisory development, and the influence of weather on fire, regeneration, and diseases.

## ACCELERATED PUBLIC WORKS

The Accelerated Public Works program has strengthened our capability for handling joint National Forest and research problems — especially on areas where timber sales are a continuing effort. The APW program has made it possible to construct field facilities on several experimental areas in northern Minnesota, northern Wisconsin, and Michigan (fig. 2). In addition, maintenance programs were accelerated on several structures at other locations. Boundary markers were re-established and signs erected wherever necessary, and outplanting sites were installed for testing developments.





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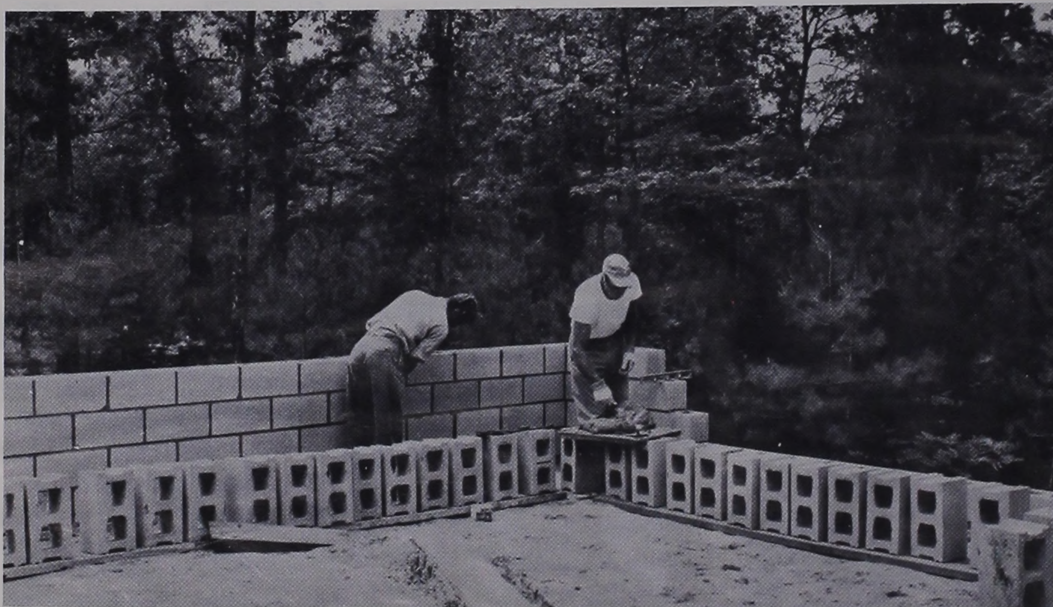
FIGURE 1. — Modern data processing equipment saves time and expense. However, scientists must be trained before they can make use of these machines. A large percentage of the Station's research and survey staff has received this training. In the photo, Tom Ginnaty, survey forester; Lawrence Liddiard, computer consultant; and Roland Buchman, Station statistician, inspect print-out at the University of Minnesota's data processing center.

## OTHER IMPORTANT EVENTS

The Shelterbelt Laboratory at Bottineau, N. Dak., was dedicated in 1963. The building, located on the campus of the North Dakota School of Forestry, has a ranch-style architecture, in keeping with its Northern Great Plains environment. Its 6 laboratories, 10 studies, and office, lobby, library, and conference space (fig. 3) will help considerably to expedite and improve our shelterbelt research effort.

Late in 1963 the St. Paul staff moved into a new headquarters laboratory on the St. Paul Campus of the University of Minnesota. However, much remains to be done before this construction project is completed. The laboratories are not yet equipped, and the landscaping cannot be done until later in the year. The dedication has been scheduled for early fall. Planning money was appropriated last year for a Forest Engineering Laboratory at Houghton, Mich.

The Marcell Experimental Forest, near Grand Rapids, Minn., was formally established in 1963. The Forest consists of 2,254 acres owned by Itasca County, the State of Minnesota, private interests,



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FIGURE 2. — Accelerated Public Works employees lay blocks for a field building in northern Wisconsin. This and other similar structures that have been built in the northern Lake States will facilitate Forest Service management programs in experimental areas.





and the U.S. Forest Service. It is devoted to the study of bog and swamp hydrology, a little known but highly important feature of land management. The Lake States have over 15 million acres of organic soils similar to those on the Marcell Experimental Forest.

During October, Secretary of Agriculture Freeman's Forestry and Agricultural Research Advisory Committees held their annual meetings jointly in Upper Michigan and northern Wisconsin. The Lake States Station was regional host. Station repre-



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**FIGURE 3.** — The Shelterbelt Laboratory (A) was dedicated September 1963. The dedication was culminated (B) when the key to the Laboratory was presented to Paul E. Slabaugh, project leader, by Dr. George M. Jemison, Associate Deputy Chief, Research, Washington, D.C. Pictured are Z. A. Zasada, Timber Management Division Chief; Slabaugh; Dr. Jemison; and Director Dickerman. Photo at upper right (C) shows interior of library conference room in Laboratory.

sentatives took the committees on three tours of laboratories and Experimental Forests (fig. 4). Project leaders explained much of our program during these tours. This was the first visit that these advisory committees have made to the Lake States.

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**FIGURE 4.** — (A) The Forestry Research Advisory Committee, Assistant Secretary of Agriculture Baker, and Dr. V. L. Harper, Forest Service Deputy Chief, Research, met in Upper Michigan and northern Wisconsin during early October to review the Forest Service research program. (B) The Station took the group on three tours to acquaint them with the research program. Project leaders described their work at the locations where problems could be seen. The northern hardwoods, at that time, were at their peak of color.





To keep our research program aligned with the most pressing needs and to keep industry, other public agencies, and forestry schools in close contact with our program, we schedule research committee meetings and program reviews periodically. Among several such events in 1963 were two program review meetings, one at Grand Rapids, Minn., concerning conifer management research, and the other at Wausau, Wis., dealing with our work in the management, utilization, and diseases of northern hardwoods. Most of the people who attended these meetings are leaders in the wood-using industries of Minnesota and Wisconsin.

Several representatives of forestry schools and agricultural experiment stations, extension foresters, and State foresters met in northern Minnesota

during July to tour certain Station research activities. Through these and other similar meetings we maintain a close working and cooperative relationship with agencies, industries, and schools in the Lake States and North Dakota.

## RESEARCH ACTIVITIES SUMMARIZED BY PROJECTS

Over the past several years the Station has consolidated its many research studies into several major projects. This year we have asked the project leaders to relate the more important highlights of their recent activities and accomplishments for this annual report. These project reports are available for your study in the following four sections.



### Timber Management

## GENETICS OF NORTHERN FOREST TREES

Hans Nienstaedt, Project Leader  
Rhineland, Wisconsin

The work at the Institute of Forest Genetics centers around four groups of studies. They deal with: (1) the genetics of *Picea*, (2) the genetics of *Betula*, (3) the effects of atomic radiation on our northern forest tree species, and (4) the basic physiological factors controlling the rooting of cuttings from trees. Many studies are in progress within this overall grouping. A few which have been in the foreground during the past year will be discussed in more detail in the following paragraphs.

### Fourth White Spruce Seed Source Planting Completed

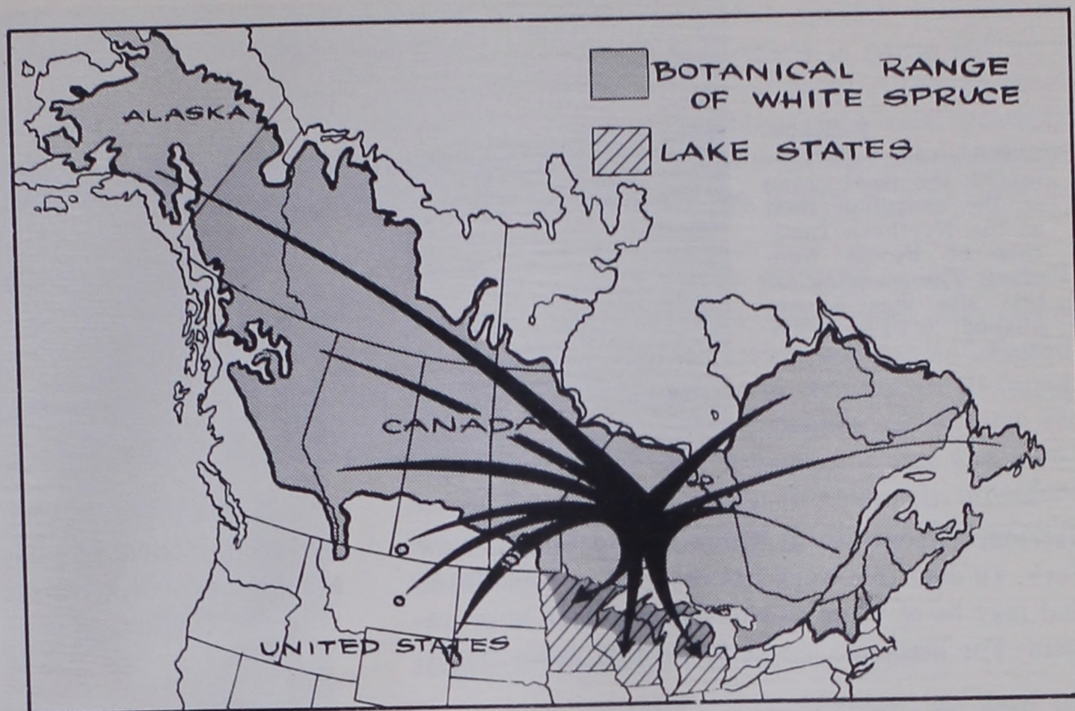
An important part of our research effort is directed toward determining the extent of genetic diversity within a species. Although we are conducting these experiments with a number of different species, we have progressed farthest with white spruce. The fourth seed source study of *Picea glauca* was field planted in 1963 (fig. 5).

The first of these white spruce racial variation studies was established in 1936 when seed of seven sources from various parts of the species range was planted east of Eagle River, Wis. Since then we have established three other related studies: (1) six test plantings involving 28 sources covering the entire range of white spruce; (2) a plantation covering seed sources from portions of southeastern Ontario and southwestern Quebec; and (3) the study just field planted at 3 sites in Michigan and Wisconsin, which includes 25 sources from Upper Michigan.

These studies, generally speaking, are too young to provide conclusions regarding the behavior of different seed sources of white spruce in the Lake States. However, two have indicated that sources from southern Ontario are well adapted to northern Wisconsin climatic conditions and actually outperform local sources. Experimental plantings of this seed source on a commercial scale are now being planned.



FIGURE 5. — In a series of four studies, white spruce seed from the entire North American range of the species has been planted in the Lake States. As the young trees develop, those seed sources that are best suited to the Lake States can be selected for future commercial plantings. Similar experiments are underway for other species.



#### **Late Flushing White Spruce Clones Show Less Spring Frost Injury**

Clonal tests of 25 white spruce trees selected for early and late flushing indicate a high degree of heritability in the broad sense of resistance to spring frost injury. In 16 late flushing clones, frost injury to the buds in the spring of 1963 varied between none and 44 percent. Early flushing clones, on the other hand, suffered between 68- and 100-percent bud kill.

The results indicate rapid genetic gain in a breeding program to develop late flushing, frost-injury-resistant new strains of white spruce. This factor and other characteristics of commercial importance are now being studied at the Institute of Forest Genetics in a progeny test of 115 open-pollinated progenies from selected white spruce trees. The test was established in the nursery during the 1963 season.

#### **Jack Pine Needle Fascicles Can Be Used for Vegetative Reproduction**

If needle fascicles of pines could be easily rooted, somatic mutations induced by gamma irradiation could perhaps be recovered and used in a breeding program. Studies indicate that rooting can be accomplished and normal plants will develop if young plants of jack pine are used and the fascicles are permitted to develop buds prior to the time they are placed in the rooting medium.

Bud development is obtained by shearing the seedlings.

In one study, rooting and subsequent growth was obtained in 70 percent of the fascicles from 2-year-old trees. The fascicles were propagated under 20-hour photoperiod in a heated rooting medium and treated with one-tenth of one percent of the hormone, IBA. It was further demonstrated that fascicles without preformed buds root but invariably fail to develop shoots. Fascicles from the current growth of 5-year-old trees do not root as well as fascicles from that of 2-year-old trees.

#### **Establishment of 6½-Acre Radiation Field Underway**

The facilities are presently being prepared for study of radiation effects on forest trees. A 6½-acre radiation field is being established, and small units for greenhouse treatment of trees and for seed and pollen irradiation are being planned (fig. 6). The first plants will be established in the radiation field in the spring of 1964 so that they can be in good vigorous growing condition when the cesium 137 radiation source is installed. These facilities will permit studies of chronic, as well as acute, radiation effects on all of our major tree species.

While the radiation facilities are under construction at Rhinelander, preliminary work is being carried on in cooperation with the Brookhaven



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FIGURE 6. — Surveyors establish the final grade of the radiation field at the Northern Institute of Forest Genetics. The clearing of this site was accomplished with APW funds.



National Laboratory at Upton, Long Island, New York. To date this work has resulted in some leads that may be of value in white spruce tree improvement. For instance, it was found that seeds result-

ing from pollen irradiated with certain dosages are heavier and germinate better than those from untreated pollen.

## PLANTATION MANAGEMENT

Richard M. Godman, Project Leader  
Cadillac, Michigan

Three million acres of plantations comprise nearly three-fourths of the pine acreage in the Lake States. With proper management to improve the size and quality of their products, these and future plantings should yield most of the pine timber needed in the region. We are studying the various cultural methods to determine how the plantation manager can use them as tools for producing the best quality and largest volume of forest products. The following is a summary of what we have learned during the past year.

### Spacing Influences Merchantable Yield

Plantation growth is strongly influenced by regular spacing. At early ages plantations tend to produce large volume yields because of high survival and rapid basal area growth. Products produced at later ages, however, tend to be small because of the high density of trees per acre. This is not true in irregularly spaced natural stands. Recent studies show that this disadvantage can be readily overcome by proper initial spacing and early thinnings.

TABLE 1. — *Effect of initial spacing on yield of jack pine at 23 years of age, site index 48, per-acre basis*

Spacing interval	Survival	Avg. d.b.h.	Basal area	Total cu. vol.	Cord volume to:	
					3-in. top	4-in. top
<i>Feet</i>	<i>Percent</i>	<i>Inches</i>	<i>Sq. ft.</i>	<i>Cu. ft.</i>	<i>Cords</i>	<i>Cords</i>
1½ x 1½	35	1.7	105	1,552	0.0	0.0
3 x 3	67	2.5	116	1,311	0.0	0.0
5 x 5	88	3.3	90	1,003	2.2	0.7
7 x 7	99	4.0	76	810	4.3	1.3
9 x 9	100	4.4	56	615	4.0	2.4



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FIGURE 7. — Straight stems with little taper and with satisfactory live crowns have developed in this 23-year-old jack pine plantation. The trees were planted at 7x7-foot initial spacing on a Grayling sand soil, site index 48.



The influence of initial spacing interval on yield of merchantable products is borne out by a 22-year-old jack pine spacing study. Although basal area density and cubic volume yield were inversely related to spacing in this study, merchantable volume yield and tree size tended to vary directly (table 1).

Initial spacings of 7x7 feet (49 square feet of growing space) per tree thus yield more merchantable products than closer spacings and should probably be the minimum to consider in all forest plantings (fig. 7). The influence of spacing on stem form, crown development, and size and number of branches appears to be relatively unimportant, compared to the effect on the yield of salable material.

#### Judicious Thinning Produces Best Growth

In most plantations, thinnings can be used to obtain the highest yield of integrated products within a desirable rotation. Periodic reduction of stand density, to stimulate and redistribute the growth on crop trees, should yield a maximum net value of products. A study in red pine shows that successive thinnings to a residual basal area of 80-100 square feet per acre will provide near maximum volume growth, both per acre and per tree, and should produce the highest quality products in the final harvest (fig. 8). Residual basal area den-

F-500598

FIGURE 8. — A twice-thinned 51-year-old red pine plantation with 87 square feet of basal area now has 20.2 cords per acre. The annual growth rate has averaged 1.9 cords per acre and 0.32 inches in average stand diameter since the second thinning.





sity has a more important effect on growth and yield than cutting method.

Following the first thinning, the trees undergo a major adjustment to increased growing space. Although red pine growth tends to differ but little at 60-140 square feet of basal area after the second thinning, tree size, volume cut at successive thinnings, and growth are greatest at residual densities of 80-100 square feet. Studies suggest that the maximum merchantable yield of more intolerant species will occur at even lower basal area levels. Thinnings should be made when

the stand attains a basal area of 140-150 square feet in red pine and at lower densities for intolerant species, such as jack pine. Although the size of the final product is readily increased by successive thinnings, its value can be increased even more by pruning the persistent dead branches to improve quality. The rate of individual tree growth, size of the pruning scar, and length of the branch stub are the most important factors that determine the economic feasibility of pruning. All of these factors can be controlled by the land manager.

## SHELTERBELT ESTABLISHMENT AND MANAGEMENT

Paul E. Slabaugh, Project Leader  
Bottineau, North Dakota

The Experiment Station's shelterbelt research is presently concerned with two important problems — selecting the best species and races within species for shelterbelt growth and rejuvenating those established shelterbelts that are threatening to fail under the harsh conditions of the Northern Great Plains. These problems feature many unknowns because Plains soils and weather conditions tend to favor grass and weed growth, rather than trees. Yet, thrifty well-managed shelterbelts can provide multiple benefits — conserving soil and moisture, protecting crops, providing wildlife habitat, and adding aesthetic values — so our research in this field has many challenges. The following sections are concerned more with the specifics of this work.

### Tree and Stand Improvement

Tree improvement research was accelerated during 1963. In a continuing effort to find the best adapted races of tree species for shelterbelt use, a seed source study of Scotch pine (*Pinus sylvestris*) was installed on the Denbigh Experimental Forest. The seed came from native stands in Hungary, Sweden, Latvia, Turkey, and from nine sources extending in a narrow band across the USSR at about 55° latitude. These supplement a test of 33 USSR sources initiated in 1961.

The survey and location of 80 sample stands for a Plains-wide ponderosa pine seed source study was completed. These stands are located in areas of low rainfall in Montana, Wyoming, North Da-



F-504416  
FIGURE 9. — Ponderosa pine of eastern Montana seed source exhibits variation in traits considered desirable for use as windbreak trees. Progeny tests are being made of selected trees.



ing the dormant season. Moreover, during the peak of the growing season (early summer), the amine formulation provided equally effective top kill of oaks at concentrations as low as two-tenths of a pound acid equivalent per gallon in cuts spaced up to 4 inches apart (edge to edge) and at four-tenths of a pound at spacings up to 6 inches.

A new systemic herbicide, Tordon<sup>1</sup> or 4-amino-

3,5,6-trichloropicolinic acid, may be even more effective on hardwoods than 2,4,5-T amine in basal injections, according to first-year results. Treated were white oak (*Quercus alba* L.) and red oak (*Q. rubra* L.), growing on a very productive site (Site Index 80+) in Clinton County, Mich. (fig. 11). The first-year results are shown in table 2.

TABLE 2. — Effect on oaks of injection treatments with herbicides—2,4,5-T vs. Tordon

Herbicide	Amount applied ( ml )	White oak		Red oak	
		Stage of growth applied			
		Dormant ( Mar. 1963 )	Peak ( June 1963 )	Dormant ( Mar. 1963 )	Peak ( June 1963 )

PERCENT OF TOPS KILLED, AUG. 1, 1963

2-INCH SPACING

2,4,5-T	1	15-75	90-100	10-20	50
Tordon	1	100	90-100	100	90-100
Tordon	½	100	90-100	100	80-100
Tordon	¼	100	90-100	100	75-100

4-INCH SPACING

2,4,5-T	1	25-75	30-80	0	15-60
Tordon	1	100	80-90	60-90	80-100
Tordon	½	80-90	90	60-90	90
Tordon	¼	25-75	20-30	15-60	20-30

6-INCH SPACING

2,4,5-T	1	15	40	0	15-30
Tordon	1	80-100	90	80-100	60-90
Tordon	½	50-100	70-90	50-90	60-100
Tordon	¼	40-75	30	25-50	15-25

## SILVICULTURE OF NORTHERN CONIFERS

Robert E. Buckman, Project Leader  
Grand Rapids, Minnesota

Regeneration problems are an increasingly important phase of the northern conifers project. Indeed, one of the most serious shortcomings of Lake States forestry stems from our inability to reproduce readily and inexpensively the most valuable timber types. The problems are acute now because old-growth stands have been largely liquidated and replacement stands are not forthcoming.

### Upland Regeneration

Direct seeding may someday reduce regeneration costs considerably. Recently, Eugene I. Roe

(Research Paper LS-3) completed a resume of past direct seedings of conifers in the Lake States and adjacent areas of Canada. He concluded that these trials, particularly the ones concerning jack pine, have resulted in better regeneration than was generally believed. Experiments with improved design are now underway to assess the potential for direct seeding in the Lake States.

An adequate supply of seed is necessary for any type of regeneration. Roe (Research Paper LS-1) recently reported the results of a study of the quantity and quality of seed available in the closed cones of jack pine. He found that stands from 9 to 200 years old produced between 1.7 and

<sup>1</sup> Tordon 22K developed and manufactured by Dow Chemical Company.





F-500557  
 FIGURE 12. — Broadcast burning of black spruce slash on the Big Falls Experimental Forest in northern Minnesota. This fire reduced the heavy concentrations of slash and at the same time prepared a favorable seedbed. Holdover fires have not been a serious problem in peat soils when the water table is within one foot of the surface.

5.8 pounds of seed per acre. Also, a thinned 40-year-old stand contained more than three times as much seed as an adjacent unthinned stand.

Another study of seed production is continuing in the 90-year-old red pine on the Cutfoot Experimental Forest. The study was begun in 1957, a year with a bumper seed crop. No differences were found in the number of seeds per acre between stands maintained at 60, 80, 100, 120, and 140 square feet of basal area per acre. Over a million seeds per acre fell, most of it in October and the following April to June. However, practically no seed has been produced in these stands since 1957 (Roe, Research Note LS-36). Studies are underway to better forecast these erratic seed crops a year or two in advance.

### Swamp Regeneration

The regeneration of swamp conifers has some bright aspects. Although the feather mosses, brush, sedges, and concentrations of logging slash are unfavorable seedbeds, compacted peat (from skid roads), sphagnum moss, and burned peat favor the regeneration of black spruce. Several trials of prescribed burning on peatlands have been attempted to create sizeable areas of burned peat and to reduce the area covered by slash, feather mosses, brush, and sedge. The results of these trials are promising, in terms of regeneration. Also, by burning when weather and peat moisture conditions were favorable, we kept the fires out of the deeper peat layers and extinguished them afterward with little difficulty (fig. 12).



F-500572  
 FIGURE 13. — An uncut stand of mixed conifers in a swamp in Upper Michigan. Clearcutting in patches or strips has proven to be most favorable for regeneration.



The mixed conifer swamps, so common in the more easterly portions of the Lake States, reproduce best with clearcutting in patches or strips according to John W. Benzie (Research Paper LS-4). This work was done in Michigan's Upper Peninsula. Partial cutting to reproduce all-age stands not only gave poorer regeneration but resulted in increased mortality in the residual stand. These results agree substantially with those obtained in Minnesota's pure black spruce types (fig. 13).

A paper published in *Ecological Monographs* by Dr. M. L. Heinselman describes an extensive study of the factors affecting the productivity of peatland in Minnesota. This work has now been extended to include the large Seneey bogs in Upper Michigan. Apparently the same factors affect bog fertility in both Minnesota and Michigan — slope of the bog and presence or absence of mineral-enriched water, depth of sphagnum peat, etc. It is important to recognize which peatlands are incapable of producing merchantable timber, for these areas are tempting targets for reforestation.

#### Prescribed Burning on Uplands

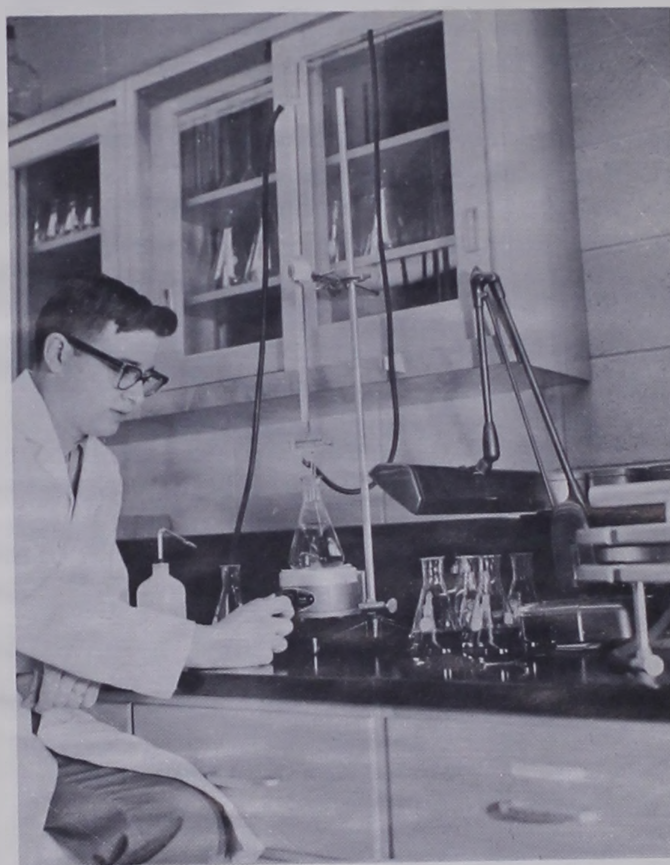
Prescribed burning has also been done on uplands, and the following important results were obtained this past year:

Hazel (*Corylus* spp.) is the most widespread and objectionable upland brush in Minnesota. Its aerial stems are easily killed by fire. After spring burning, however, hazel resprouts prolifically and continues to do so after repeated fires. Sprouting is less vigorous if the burning is done in the summer. In fact, repeated summer burning appears to reduce and eventually eliminate hazel clones. If the humus or organic mantle above the mineral soil is dry enough to burn, as it was in the summer drought of 1961, underground stem systems of hazel can be eliminated by a single fire.

Aspen (*Populus tremuloides*), unlike most hardwood trees and shrubs, seems to show a decline in vigor and abundance of root suckering after repeated spring burning. In a prescribed burning experiment at Six Mile Creek on the Chipewewa National Forest, five plots that were burned twice, 2 years apart, showed a 50-percent reduction in suckering after the second fire. The second crop of suckers was somewhat less vigorous than the first, averaging 0.5 foot shorter (2.8 versus 3.3 feet). Still other plots (not designed to study this unexpected response) had a 68-percent reduc-

tion in suckering from the first to second fire, an 86-percent reduction after three burns, and a 94-percent reduction after four burns. This finding, if confirmed by additional trials, could have widespread significance in the Lake States because: (1) the spring season offers the most dependable and predictable burning weather, and (2) we expect to convert some aspen lands back to conifers and to open areas for wildlife.

Superimposed on a prescribed burning experiment on the Cutfoot Experimental Forest is a study of fire effects on soil chemistry. No difference is evident in nitrogen, potassium, phosphorus, or calcium between any of the burned and unburned treatments (fig. 14). Some compartments have been burned three times either in the summer or in the spring. Burning has removed up to 25,000 pounds of organic material per acre; whether continued burning will eventually cause a reduction of nutrients in the mineral soil remains to be seen.



F-500466

FIGURE 14. — Donald McCain, laboratory technician, analyzes chemical properties of a forest soil from a prescribed burning experiment. There is no difference in N, P, K, or Ca between unburned soils and those burned three times.



# SILVICULTURE OF NORTHERN HARDWOODS

Carl Arbogast, Jr., Project Leader  
Marquette, Michigan

Much of the research that we will discuss has a direct bearing on important timber and game habitat management problems. Work has been completed on one study of the relation between deer population and browsing damage to timber reproduction and on a group of related investigations of the reproduction growth following partial cutting. Studies are still in progress on the amount and development of epicormic sprouts after cutting. These sprouts reduce the quality of growth on cutover areas.

## Pellet-Group Surveys Don't Always Show Deer Use Accurately

In the spring of 1962 a pellet-group survey, in conjunction with a browse survey, was made on the Argonne Experimental Forest in northeastern Wisconsin to obtain population estimates and help evaluate winter deer-browsing pressure. Since certain timber types within this 6,400-acre tract seemed to be more heavily used than others, the sample was stratified into three broad groups. These were: upland type, all high land on which a single forest type was predominant; swamp type, all low land on which a single forest type was predominant; and mixed type, which included both high land and low land where two or more distinctive forest types were adjacent to one another.

The pellet survey showed that the swamp and mixed types were the areas where the deer populations seemed heaviest. However, the northern hardwoods in the uplands showed the most browsing. The tabulation below shows this comparison.

Cover type	Deer population estimate <sup>1</sup>	No. of stems per acre <sup>2</sup>	Percent browsed <sup>3</sup>
Upland	19.1± 9.2	924	60
Swamp	36.5±12.0	862	14
Mixed	36.4±15.5	770	45
Average	27.4± 6.8		

<sup>1</sup> Estimated number of deer per section with 95-percent confidence limits.

<sup>2</sup> Stems of tree species from 2 feet to 7 feet tall.

<sup>3</sup> Browsing on apical terminals only.

The deer rested and perhaps fed on browse other than tree reproduction in the swamp-conifer

and mixed types, going into the northern hardwoods in the uplands only to feed. Consequently, pellets were dropped where the deer spent most of their time — in the swamp-conifer and mixed types — while the important browsing on tree reproduction occurred in the uplands. These data indicate that pellet counts in some situations may not show true deer use relationships.

## Development of Reproduction Following Partial Cutting

During the past 2 years we have been studying the development of seedlings and saplings in connection with cutting experiments on the Upper Peninsula and Argonne Experimental Forests. This is an effort to develop standard growth curves for comparison in stands that have sustained various degrees of deer browsing. We hope eventually to be able to place a quantitative value on damage to timber products due to deer browsing. The sampling has been done to determine density, stocking, species composition, annual growth, and age-height relationships.

Comparison of seedlings in a variety of stand conditions shows that overstory density has a major effect on height growth (fig. 15). For example, 13 years after an old-growth stand was selectively cut to 70 square feet of basal area per acre, the height of the understory stems exceeded the height of comparable stems in an uncut old-growth stand by about 7½ feet. This illustrates both the effect of overstory density and the ability of sugar maple seedlings to persist under unfavorable conditions.

This study has also shown some fundamental differences between old-growth and second-growth stands in patterns of regeneration development before and after cutting. Ten years after cutting in an old-growth stand, only 20 percent of the seedlings and saplings present were less than 10 years old. None of these younger stems had been able to express dominance with respect to other seedlings and saplings. Ten years after cutting in a second-growth stand, 60 percent of the seedlings and saplings present were less than 10 years old and 40 percent of the dominant and codominant stems in the regeneration stand were less than 10 years old.





F-503372

FIGURE 15. — A second-growth stand of northern hardwoods before cutting. Note the absence of advanced regeneration.

Evidently, advanced regeneration in the old-growth stand inhibited the development of new regeneration after cutting much more than it did in the second-growth. Both stands have about the same stocking, but seedlings and saplings are taller and older in the old-growth than in the second-growth stands, even though both were cut at the same time.

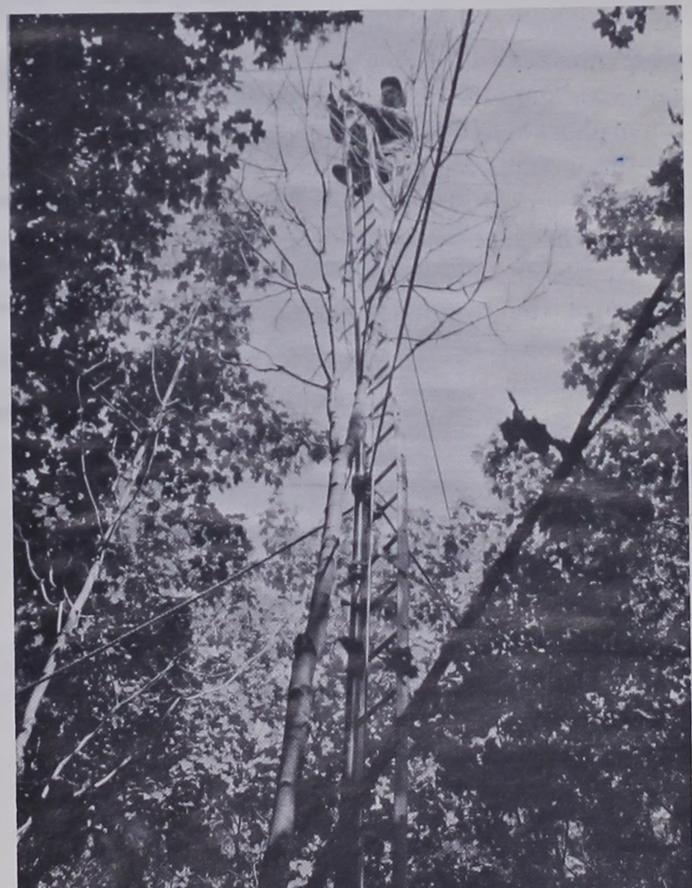
#### **Epicormic Sprouting Studied Through Use of Radical Treatments**

Two studies have been established on the Argonne Experimental Forest in northern Wisconsin to develop more information about epicormic sprouting. When dormant buds sprout on the boles of trees, the resulting limbs reduce the quality of logs. We do not know all of the conditions that encourage such sprouting. These studies were established to create a number of conditions that are possible causes.

The crowns of many trees in several age classes were intentionally damaged. The leaves were removed from some, while others were stripped of all living twigs, all living branches, or the entire

F-504616

FIGURE 16. — A technician using a telescopic pole and ladder device removing leaves and twigs from sugar maple.





crown (fig. 16). Certain of the trees were left in normal shading conditions, while others were exposed to direct sunlight. The defoliations were tried at different times of day, also, to see if that had any important effect.

Preliminary observations indicated that tree size and age have an important effect on shoot abundance — twice as many shoots developed on the small poles as on the medium-sized trees. Shading was important, too — more than three times as many shoots developed on the trees that were exposed to direct sunlight. Crown class was unim-

## SITE REQUIREMENTS OF LAKE STATES TREES

Richard F. Watt, Project Leader  
St. Paul, Minnesota

The Site Requirements Project has been concentrated for a second year on mineral nutrition of black spruce in the bogs of glacial Lake Agassiz in northern Minnesota. Initial work with foliar samples collected from varied sites on the Big Falls Experimental Forest showed that the contents of both nitrogen and phosphorus decrease with site index. On the best sites, both of these elements seemed to be available in sufficient quantities when compared with the foliar content found in nutrition experiments by other workers, generally with other species of spruce. But nitrogen and phosphorus were low on poor sites.

A fertilization experiment was installed in the spring of 1962 to confirm the tentative diagnosis of phosphorous and nitrogen deficiencies on the poor muskegs of the Experimental Forest. Nitrogen (ammonium nitrate) and phosphorus (treble superphosphate) were applied singly and together in three replications at the rate of 300 pounds each of elemental nitrogen and phosphate per acre during the 1962 and 1963 growing seasons.

At the end of the first season, the only visible effect of the treatment was the browning of the mosses, especially those on the higher mounds. When growth started the second season, however, the effects of treatment were strikingly visible. Fertilized trees started growth earlier in the season, and the foliage of all ages — especially that receiving nitrogen — had a decided blue-green color, rather than the yellow-green of the unfertilized trees. Their needles were also longer, and the shoots seemed more vigorous.

Measurements made at the end of the 1963 growing season showed that the terminal leader

portant on small poles, but three times as many shoots developed on the intermediates as on the codominants in the larger and older trees. Defoliation at different times of day had no significant effect. The technique of defoliation directly influenced the pattern of refoliation. Where leaves were removed, most new shoots developed from axillary buds at twig ends. Where twigs were cut off, new foliage developed in clumps along the upper portions of the main branches. Where branches and tops were removed, new shoots were confined to the upper portion of the main bole.

growth of trees fertilized with nitrogen plus phosphorus was more than four times the average growth during the previous 3 years (fig. 17).



F-506307  
FIGURE 17. — Terminal growth on this tree fertilized with nitrogen and phosphorus has been increased about four times over that of previous years, as indicated by the markers.



With nitrogen alone, the increase was 2.8 times; with phosphorus alone, it was 1.5. But, leader growth of control trees was only 1.2 times that of the previous years. Smaller but corresponding increases in growth of branch shoots were also found, and the length and the dry weight of needles increased.

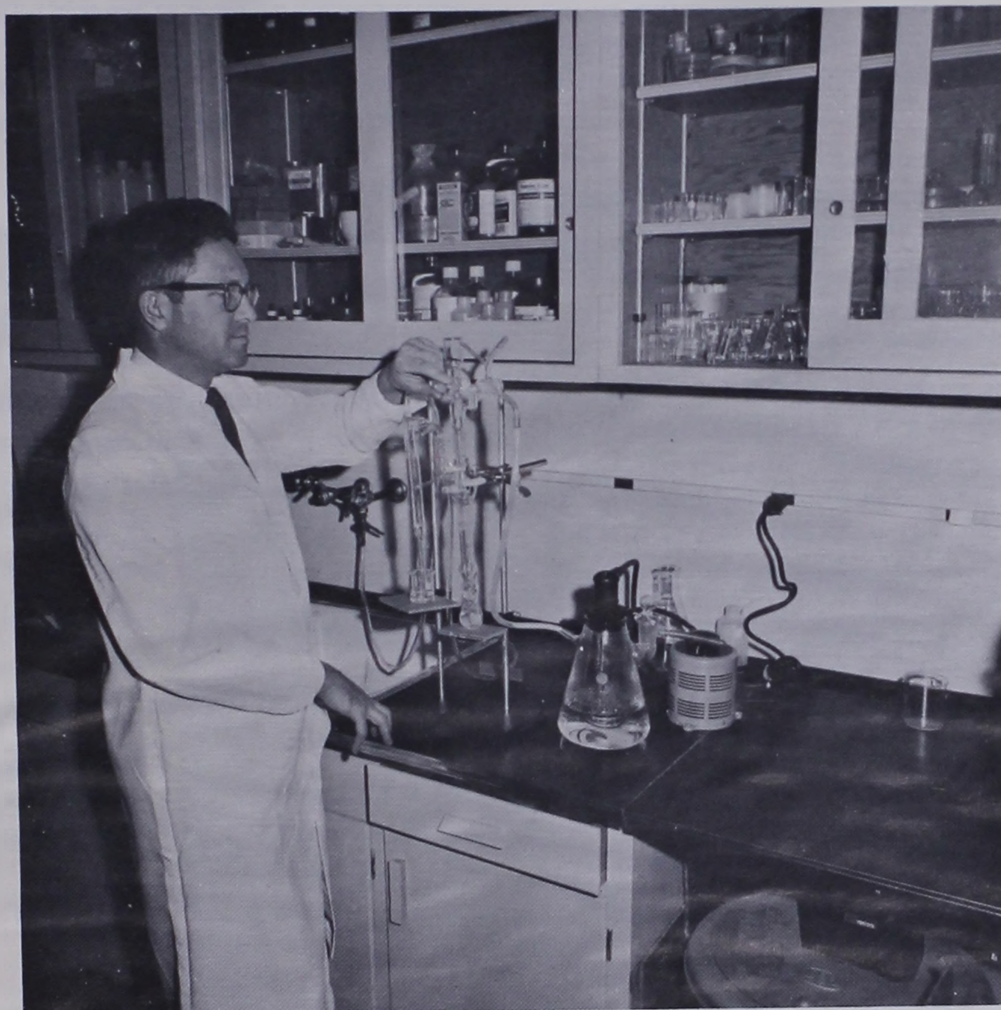
Great changes in understory plants were evident the second season. The ericaceous woody shrubs of the bog were growing luxuriously, but the mosses appeared to be almost completely killed. No change in shrub composition was apparent.

We will continue taking measurements to determine the duration of response to the original treatments and changes in diameter, height growth, and levels of foliar nutrients.

Analysis of foliage (fig. 18) collected on an-

other series of transects from a nearby bog with somewhat different ecological conditions, principally the presence of good site but with no alder to add nitrogen, disclosed that low nitrogen and phosphorous levels limited growth on that bog, too, but in a somewhat more complicated fashion than on the poor site.

Fertilization experiments have also been installed in the Upper Peninsula of Michigan in an area where red pine plantations have been virtually eliminated by a malady of unknown cause, "Jones' Disease." Examination in the fall, following application of the fertilizers, disclosed no response. Foliage samples have been collected from both the fertilized plots and from other plantations, both healthy and diseased; perhaps these will yield information on possible mineral nutrient involvement in this baffling disease.



F-506319

FIGURE 18. — Project Leader Dr. Watt uses micro-Kjeldahl equipment to determine nitrogen content of black spruce foliage. This equipment, which requires only very small needle samples, allows repeated sampling of trees without damage.



# Watershed, Recreation and Wildlife Habitat Management

## BOG AND SWAMP HYDROLOGY

Roger R. Bay, Project Leader  
Grand Rapids, Minnesota

### Streamflow from Bog Watersheds

Considerable information is accumulating from the five bog watersheds that are being calibrated on the Marcell Experimental Forest in northern Minnesota. For example, we learned that during the runoff period of 1962 (April to December), 65 to 80 percent of the total runoff from the instrumented bogs occurred during 2 months in spring. Thus, not all bogs are good regulators of streamflow over the entire year. This is due to the physical characteristics of each watershed area and to the hydrologic properties of the peat soils within each bog.

Eventually, these calibrated bogs will be treated with various timber management or water control techniques to determine what effect such treatments have on water yield from bog areas.

### Aquifer Characteristics of Peats

Recent studies have shown striking differences in rates of water movement between different peat types. Hydraulic conductivities, or water movement rates, as high as 118 feet per day were measured in surface horizons of undecomposed moss peat, while water movement through deeper decomposed peats was as low as 0.016 foot per day.

These results indicate that in some bogs the surface horizons are most important to watershed management because of their higher specific yield and higher rates of water movement. The deeper, more dense horizons provide little potential storage capacity, and their water movement is very slow. Based on these two characteristics — hydraulic conductivity and specific yield — some peats can be judged as very poor aquifers. On the other hand, certain peats possess good aquifer characteristics much like some mineral soils (table 3).

These studies are being extended to other peat types commonly found in the Lake States.

### Evapotranspiration from Bogs — A New Study

Evapotranspiration is an important means of water removal from a land area. This may be particularly true in bog watersheds because of their high water tables and relative abundance of available water. Researchers have studied this process in many regions and in many plant communities, but not in the Lake States peatland types. To fully understand bog hydrology and to assess water loss from northern bogs, it is necessary to evaluate the evapotranspiration losses of natural vegetation and

TABLE 3. — Aquifer characteristics of several peats and mineral soils

Soil type	Porosity	Specific yield	Water movement rate	Aquifer class <sup>1</sup>
	Percent	Gal./cu. ft.		
Moss peat (undecomposed)	95-99	6.43	Rapid	Good
Decomposed peat	81-85	.75	Very slow	Poor
Clean gravel <sup>1</sup>	30-40	1.87	Very rapid	Good
Glacial till <sup>1</sup>	40-50	.37	Very slow	Poor

<sup>1</sup> Aquifer classes and mineral soil values from: Todd, D. K. *Ground water hydrology*. 336 pp., illus. John Wiley & Sons, Inc., New York, 1959.



to determine how land managers can alter these losses.

Water losses from small plots in bog areas are now being studied by project personnel (fig. 19.) These plots are formed by driving galvanized steel cylinders into the peat profile with the bottoms extending into a horizon of dense peat. The cylinders, 10 feet in diameter and 3 feet high, form bottomless tanks in which water table changes are due to evaporation and/or transpiration. Some of these plots have been installed in open areas, some in timber stands, and others in recently cutover plots. They will enable researchers to evaluate the relative rates of water loss in various cover types.

Precipitation, temperature, humidity, wind, and open-pan evaporation are also recorded on these plots. Water losses from different types of peatland vegetation will be related to some of these factors.

### Bog Classification

A new study concerning the hydrologic classification of northern bogs was initiated this past field season. The major objective of the survey is to make a classification of wetlands that will reflect their hydrologic character. This will provide a basis for identifying the bogs and swamps and grouping them into categories. This is the first and basic step toward evaluating the basic hydrologic characteristics of our northern wetlands and their response to treatment.

Past classification systems in Europe and the United States have generally been concerned with peat origin and the ecological aspects of bog vegetation. However, from the watershed manager's point of view, some system of classification is needed that emphasizes the hydrologic properties of boglands. This study will continue for several more field seasons.

F-506098  
FIGURE 19. — Bottomless tank lysimeters located in an open bog measure evapotranspiration from moss and shrubs. Climatological data are collected at the weather station shelter, rain gage, and class "A" Weather Bureau evaporation pan. Dr. Don Boelter measures water loss in the large tanks.





# GROUNDWATER HYDROLOGY AND STREAMBANK EROSION

W. David Striffler, Project Leader  
Cadillac, Michigan

Watershed management research in Lower Michigan is primarily concerned with the effects of forest cover on ground water supplies and on sediment reduction in trout streams through bank stabilization. These two subjects reflect problems that have a broad application in the northern forested region of the Lake States.

In this region of coarse-textured glacially derived soils, very little water from rainfall or snowmelt goes directly into streamflow. Instead, it soaks into the ground and enters the ground water body, so the study of ground water is the most direct way to evaluate forest management effects. Similarly, the glacially derived soils are highly erodible, especially in streambanks. Sediment from eroding banks may cause severe damage to the trout habitat.



F-504475

FIGURE 20. — This recording well on the Udell Experimental Forest keeps a continuous record of water table depth. Continuous recording provides records of unusual fluctuations which may occur between regularly scheduled tape measurements.

## More Observation Wells Established

Periodic measurement of ground water levels in the network of wells on the Udell Experimental Forest enables us to evaluate the seasonal trends of recharge and depletion under various forest types. Eventually, we will evaluate the effects of land-use treatments. Wells and well installations are an important part of the project.

Ten new wells and 10 shelters for recording wells were installed last year on the Forest. Seven of the new wells were located in morainal uplands where ground water is sometimes 230 feet below the surface. These new wells, important reference points in our grid well system, permit study of the relationship between recharge timing and water table depth for all conditions on the Experimental Forest (fig. 20).

## Studies Provide Basic Data on Recharge and Drift Materials (In cooperation with Michigan State University)

To interpret delays between recharge events and water table response and to translate water table fluctuations into meaningful values, we need to know much about the properties of the aquifer and overburden materials. Two cooperative studies with Michigan State University are providing some of the answers.

The Geology Department has completed a survey of drift materials and ground water tables, using both seismic refraction and electrical resistivity techniques. These data will eventually permit us to map out the boundaries of the ground water basins on the Experimental Forest, using the logs from our new wells as reference points. We will also be able to define the depth and nature of the overburden materials.

In the other cooperative effort, the Soils Department is studying the process of vertical percolation of water through overburden materials. The successive saturation and drainage of definite stratigraphic zones in the overburden profiles is being measured with a nuclear moisture probe on a long cable. Slow percolation within these zones



accounts for the long drainage time required for well levels to respond to recharge.

### Forest Type Affects Ground Water Recharge

Ground water budgets for the water years 1961-62 and 1962-63 are being compiled for several pine plantations and native hardwood forests. The importance of snowmelt in the recharge of shallow ground water aquifers is especially evident. During the past year, for example, snowmelt contributed 6.3 inches of the total recharge of 9.3 inches under a 22-year-old red pine plantation. The snowpack varies with the crown density of the forest type. Thus, hardwood forests with open crowns during the dormant season generally have heavier snowpacks than dense young pine plantations.

### New Streambank Rehabilitation Methods Tried

Eroding streambanks are a major source of sediment in Lake States trout streams. Streambank treatment has traditionally involved mechanical

stabilization at the foot of the bank and revegetation of the upper bank. Revegetation has largely been limited to seeding and fertilizing.

In an effort to develop more economical means of streambank stabilization, we are testing various methods of quick cover establishment on eroding banks (fig. 21). We have selected a number of sample banks and installed various combinations of waterline and upper-bank treatments. The upper-bank treatments included various types of spray-on chemical mulch and soil stabilizers. Six different types of materials were tested, including asphalt emulsion, other petroleum products, and several latex products. All of these products were designed to prevent soil erosion, hold seed in place, conserve moisture, and yet permit germinating seedlings to emerge through the cover.

Initial results indicate that all materials tested help establish quick grass cover on steep eroding banks. Evaluation over a period of time will show how the treatments and cover hold up and whether vegetation alone can successfully stabilize a bank.

F-506035  
FIGURE 21. — Installing test plot on treated portion of bank. Here a latex mulch is applied after the bank has been seeded, fertilized, and watered. Waterline has been rock riprapped.





## RUNOFF AND EROSION REDUCTION

Richard S. Sartz, Project Leader  
LaCrosse, Wisconsin

### First Phase Done —

#### 28 Watersheds Instrumented

Research on the complex land use-water problems of the Lake States' unglaciated Driftless Area, begun 5 years ago at La Crosse, Wis., is now moving into a second phase. During the first 5 years our main effort went toward establishing an experimental forest and instrumenting selected watersheds for measuring rainfall, runoff, and soil loss. This is the backbone of a watershed management research program.

Four more watersheds were instrumented in 1963, essentially completing this phase of our program. The 28 watersheds under study include, by land-use type: 5 in forest areas (including 1 grazed); 4 in steep, openland pastures; 3 abandoned field areas (upland); 5 in croplands (upland); 3 in meadows (upland); and 8 composite areas. The composite watersheds include ridgetop openlands and the forested slopes below them. These, together with the upland watersheds, make up a study on the effect of the forested slopes on the disposition of runoff from upland fields.

The runoff stations are equipped with automatic water-level recorders, which trace the runoff record on a chart, and with automatic stage water samplers for measuring suspended sediment. Watershed rainfall is determined from a network of 14 non-recording and 3 recording rain gages.

These studies must produce several years' data before accurate conclusions can be drawn, but the following tentative conclusions can be made:

1. Ungrazed woodlands yield practically no surface runoff.
2. Abandoned fields with grass or weed cover yield little surface runoff.
3. Runoff from upland fields during most summer storms is dissipated on the forested slopes and never reaches the valley floor.

#### Planting Studies Yielding Results

In the spring of 1961 a study was begun to evaluate early survival of planted trees of different species and ages. Eastern redcedar and jack, ponderosa, and Austrian pine were planted on a south-facing slope, while eastern white pine, Nor-

way and white spruce, and European larch were planted on a north-facing slope. Red and Scotch pine were planted on both aspects. First year survival for all species and age classes was quite high — from 85 to 96 percent — except for an extremely droughty rocky site where survival was 76 percent. During the second year, survival dropped 1 to 4 percent. A comparison of red pine stock showed that more transplants survived than seedlings, and 2-0 was superior to 3-0 in three of four trials.

In another study, 3-0 and 2-1 red pine were compared by five ground preparation methods. The first four, all hand planted, were bulldozed contour terraces, plowed single furrow, plowed double furrow, and hand scalped. The last method made use of a Lowther tree planter. The only significant differences in survival were in the 3-0 stock. Both the single-furrow and tree-planter methods were better than scalps (statistically significant at 10-percent level). Survival of transplants was slightly better than that of seedlings in all five methods of ground preparation but statistically better only in the case of scalps. However, when survivals were expressed in terms of only the high-vigor trees, transplants averaged 17 percent better than seedlings and were statistically better than seedlings for each of the five methods of ground preparation.

#### Move into Fundamental Studies

To better understand the hydrologic importance of forests in the Driftless Area, we are beginning to study the soil and water relationships of both planted and natural stands. In one study we are investigating the influence of plantation establishment and growth on soil moisture, snow accumulation, and snowmelt; on litter accumulation; and on bulk density and chemical properties of the soil. Red and white pine and red oak are being studied on both north and south slopes. Norway spruce and European larch are being studied on north slopes only. The first set of soil moisture and bulk density measurements was taken last summer. Measurements will be repeated at specified intervals as the stands grow.



In another study, we will try to determine how three different coniferous species — white pine, Norway spruce, and European larch — affect soil freezing and runoff from frozen ground. Also being tested are different methods of measuring deep frost penetration, and a trial runoff installation. In a separate study, the influence of forest litter on soil freezing and runoff in native hardwood stands will be investigated.

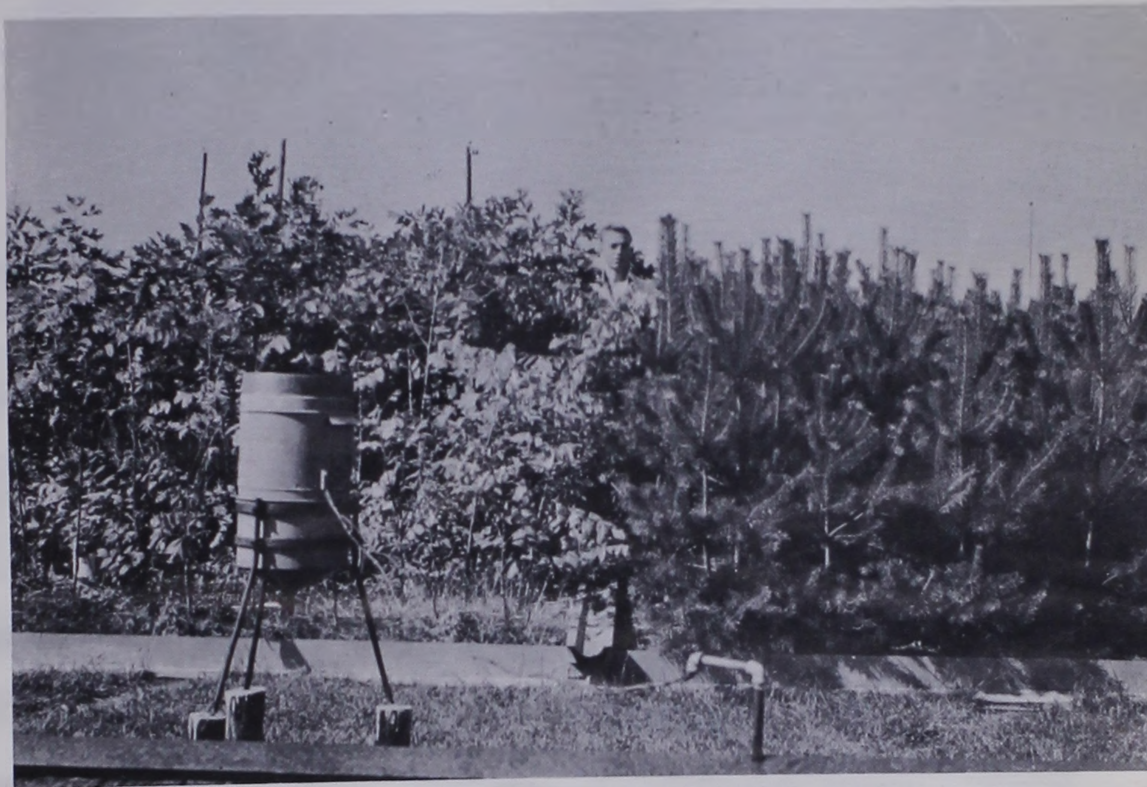
#### Lysimeter Study Analyzed

Analysis of records from a lysimeter study in the 1930's showed how strongly litter and grass

cover affect storm runoff and erosion on the loess soils of the area. Five lysimeters were planted to five different cover crops: hardwood seedlings with mulch, Scotch pine seedlings with needle mulch, hardwood seedlings without mulch, bluegrass sod, and annual grain (fig. 22).

Growing season runoff averaged about 0.5 inch for the mulched seedlings and grass, as compared with 3.7 and 6.5 inches for the unmulched seedlings and grain, respectively. The effect of cover on soil loss was even more striking. Annual losses averaged 0.05 and 0.23 ton per acre for the mulched seedlings and grass plots, and 4.05 and 20.06 tons for the unmulched seedlings and grain plots.

F-402992  
FIGURE 22. — Water and soil losses from large lysimeters were studied in the 1930's. Scotch pine on right, hardwoods on left. This study has been carried through to completion and the final results have been published.



## SOCIAL AND ECONOMIC ASPECTS OF FOREST RECREATION

Robert C. Lucas, Project Leader  
St. Paul, Minnesota

The year 1963 was one of consolidation and planning in forest recreation research. Work centered in the office rather than in the field and the computers chewed away on data from previous surveys.

#### Use Projections — Up, But How Fast and How Sure?

Study data from the Quetico-Superior Area (the Canoe Country along the Minnesota-Ontario bor-

der) were compared to the conclusions of the Outdoor Recreation Resources Review Commission. Both sources agreed that, although many types of forest recreation may increase more slowly in the future, wilderness use seems likely to keep on climbing rapidly. It also appears from this review (and the study below) that recreational use is hard to predict. It looks as if planning must be flexible and overdevelopment avoided.





F-498987  
FIGURE 23. — The solid rock on this Canoe Country campsite can take a beating, but the vegetation cannot. All of the campsites sampled had lost considerable vegetation, and tree reproduction was absent.

### Family Campers on the Huron-Manistee National Forests

The analysis phase of the study of the social and economic characteristics of family campers on the Huron and Manistee National Forests in Michigan is nearly completed. Its objectives are: (1) to describe family campers, (2) to compare them with the general population, and (3) to determine if any relationships exist between their social and economic characteristics and camping participation rates. The results will provide information for improving use projections and helping managers of forest recreation.

The typical family camped 3 days and traveled 160 miles to the campground where they were interviewed. These two Forests provide a recreation opportunity that is in shortest supply in the United States — camping in a forest environment less than a day's drive from home.

The income distributions of campers on the two Forests were significantly different. In general, the proportion of higher income families was largest on the Huron. If camping expenditures increase with income, this may indicate that the impact on the Huron's local economy may be greatest. Occupation distributions of campers also

differed significantly, with a larger proportion of the professional and managerial people on the Huron, while more clerical-sales people used the Manistee. Only a small part of these income and occupation differences can be explained by differences in attractions or market area populations.

If use projections are based on expected numbers of people in various income and occupation classes, these results indicate that separate use projections for the Forests would differ from a combined projection.

Huron campers had camped fewer years than Manistee campers. However, over 50 percent on both Forests had camped consistently during 9 years or more prior to 1962. In contrast, on both Forests over 50 percent had camped 1 year or less on *that* Forest prior to 1962. This poses an interesting question. As campers gain experience do they prefer National Forest facilities to other campgrounds?

Significant differences have been found between campers and the general population in income, education, occupation, and number of children, indicating an association between these factors and *whether or not* a family camps. The relationship between these factors and *how much* camping a family does is still not clear. Further analysis is underway.



### Factors Related to Recreational Use Distribution

Use estimates are being finished for all Huron and Manistee National Forest recreation sites. Use distribution will then be analyzed to answer questions such as : How does distance from population centers or paved roads affect use of campgrounds, picnic grounds, or trout streams? Is use higher when campgrounds are scattered or clustered?

### Canoe Campsite Condition Study

(In cooperation with the University of Minnesota)

The Station recently cooperated with the School of Forestry, University of Minnesota, on a campsite ecology study in the Canoe Country. All sample campsites, including those which had light use (fig. 23), showed considerable loss in ground vegetation. The degree of deterioration was related mainly to the percent of the area originally covered by ground vegetation (estimated from a nearby control site) and the amount of recreational use. Position on the slope also seemed important. Visitors rated site conditions as good, however, and were generally unaware of the damage they did.

### An Improved Method for Estimating Visitors' Length of Stay

Length-of-stay information is one of the most important recreation statistics. Estimating length of stay seems easy — just ask a reasonable number of visitors and average their replies. However, in the Station's Boundary Waters Canoe Area study, average lengths of stay based on interviews in the campgrounds seemed rather long. Average figures from a sample of campers leaving the area in their cars were shorter. Investigation showed that the campground sample had a built-in bias. A simple correction was developed and published. It can be used by researchers and administrators for length-of-stay estimates for any recreation area. This is important because all interview data from campgrounds, resorts, or other recreation areas are subject to the same bias.

### Plans — Long- and Short-Term

Dr. V. L. Harper, Deputy Chief in charge of Forest Service research, visited the Station in August. He reviewed future plans and past research while on a field trip through the Boundary Waters Canoe Area (fig. 24).

Studies have shown that most Boundary Waters Canoe Area visitors do not notice and object to carefully controlled timber harvests there. In 1964, visitors in the logging areas will be further questioned to identify the aspects of logging that are noticed and disliked.

Information programs can benefit visitors and encourage their proper use of recreational resources. During 1964, the possibilities for research into communications problems will be explored at the new Visitor Information Center on the Superior National Forest.

Lake States recreation resource management problems were reviewed this year and topics needing research were identified. Top priority was assigned to these five questions:

1. How do visitors define crowding and use compatibility?
2. How can use projection methods be improved?
3. What effect does location have on amount and type of use?

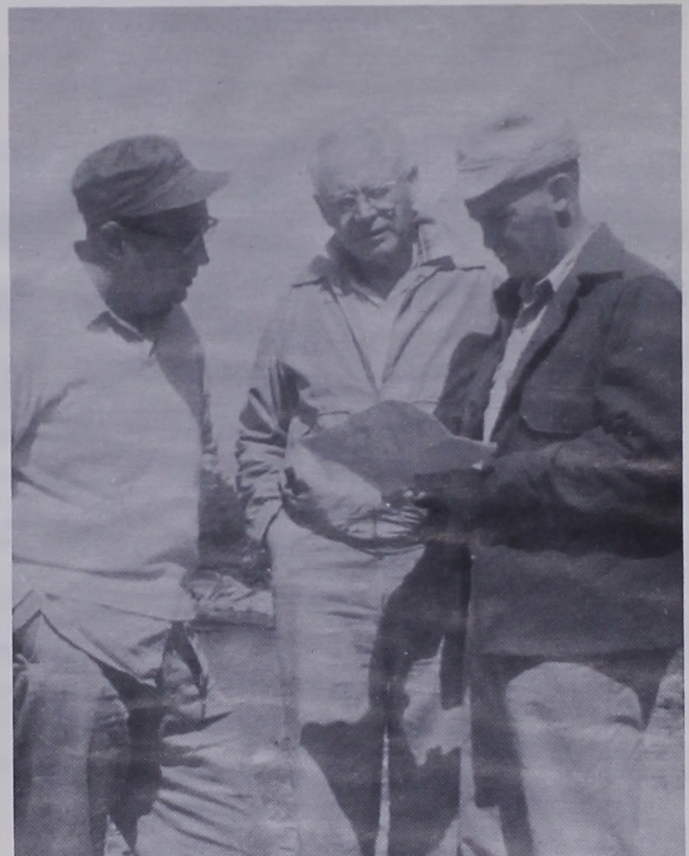


FIGURE 24. — Dr. Lucas (left), Dr. Harper (middle), and Roger Bay (right) discuss recreation and watershed programs during a field trip in northern Minnesota.



4. What are the interrelationships between different recreation suppliers — especially public and private?

5. What do different ways of developing resources cost and how do visitors evaluate them?

## COOPERATIVE RECREATION RESEARCH — UNIVERSITY OF MICHIGAN

Hugh C. Davis, Project Leader

Ann Arbor, Michigan

The Forest Service seeks to maintain a strong base of knowledge requisite to multiple use forest land management. To do this it often works closely with universities where special competence exists. The Cooperative Recreation Research Unit at the University of Michigan was established in mid-1962 to help stimulate research and training in forest recreation (fig. 25).

Now nearing completion are four studies at the University which are sponsored wholly or in part by the Station. The first deals with the public's reaction to and the problems associated with public acquisition of private lands for public recreation use. A second study seeks information on the amount of hunting taking place on Federal, State, and club and other privately owned lands in the State of Michigan.

In a third study, a faculty member and a graduate student are attempting to determine what factors should be considered in deciding the best location for a recreation area in relation to centers of population. This study approaches the problem from the point of view of the user, rather than from the supply of land and resources suitable for recreation. It considers such things as travel time, amount of demand for recreation of various kinds, location of other recreation areas which might compete for use, and the sorts of recreation available in the area.

A fourth study analyzes the functioning of a private campground located near a National Forest campground. When completed, this study should give insight for the forest landowner considering development of camping facilities.



FIGURE 25. — In addition to his research program, Dr. Hugh Davis (left) helps to plan research that is performed by graduate students at the University of Michigan, in addition to his research program. Here, he checks plans with Dr. Grant Sharpe of the School of Natural Resources.



Just getting under way is a long-term study of the social and economic factors that are behind the great increase in use of natural resources for outdoor recreation. The objective of this study is to provide a better understanding and identification of points to be taken into account when making projections of the future demand for forest recreation. An initial phase of this study is the development of a scheme for determining the recreation resource potential in certain portions of the Lake States Region. This will be done by aerial photo-interpretation. Subsequent phases may in-

clude detailed study of the recreation activities of the population in a geographical sample of the recreation "market" area.

In addition we are working closely with other recreation research projects being carried on at the University. We assist in formulating research proposals and help guide the conduct of several of these studies.

Particular emphasis is being given this year to the development of new training and research activities at the University's summer field camp in Michigan's Upper Peninsula.

## **CONIFER-ASPEN WILDLIFE HABITAT**

**Forest W. Stearns, Project Leader  
St. Paul, Minnesota**

Wildlife habitat research in the Lake States is concerned with three complex problems, namely: (1) evaluation of silvicultural practices in relation to wildlife; (2) development and evaluation of practices designed specifically to improve habitat; and (3) study of herbs, shrubs, and trees providing food and cover for forest wildlife to learn more about the life histories of these plants and their response to use by animals.

Habitat research at present is directed primarily toward two species, white-tailed deer and ruffed grouse. However, there is little question that practices which benefit these species, with a few exceptions, are beneficial to all other forest animals. Most species require diversity in habitat and are benefited by increasing forest edge where food plants prosper. Good habitat alone cannot insure abundant wildlife populations, but it does much to ameliorate weather extremes and, when weather is favorable, permits the development of vigorous populations.

### **Browse Production Under Observation**

During the past year, our research has been concentrated on the influence of silvicultural practices on the quantity and quality of deer browse produced. The winter food of deer consists largely of woody twigs called browse. Studies in cooperation with the Wisconsin Conservation Department and the National Forests continue to demonstrate that light is the major factor in browse production by any species. Only when the bulk of tree cover is removed is there an appreciable increase in browse production. In northern hardwoods, strip

clearcuts show promise of good browse production and, at the same time, permit forest regeneration. Browse production drops off rapidly as the new stand develops; hence cutting must be planned so that new production areas become available in succeeding years.

Knowledge of the browse production of different forest types and condition classes is essential if wildlife needs are to be coordinated intelligently with intensive forest management. Determination of browse production potential for major forest types was begun this year in cooperation with the National Forests.

### **Forest Openings Are an Essential Habitat Feature (In cooperation with University of Wisconsin)**

Openings are an important element in the habitat of most forest dwellers, particularly the white-tailed deer and the ruffed grouse. Openings fulfill a variety of functions. They provide food, create more edge, modify the microclimate, and serve as gathering places. In the presettlement period, openings were created by windfall and wildfire. Where the forest escaped these catastrophic factors for a long period, wildlife populations declined. In the managed forest of today persistent openings are rare, and they must be developed as needed.

To provide criteria for classifying openings and to determine methods and specifications for establishing them, the Station is cooperating with the University of Wisconsin in a study of the vegetation of natural openings (fig. 26). Preliminary findings suggest that most of the openings now





F-506118  
FIGURE 26. — G. F. Levy  
(University of Wis.)  
and A. J. Yeager (Wis.  
Conserv. Dept.) sam-  
pling soil in a large  
forest opening in north-  
ern Wisconsin.

in existence in northern Wisconsin were manmade during logging or the early settlement period. Many were the sites of logging camps, abandoned farms, or deserted settlements and have been maintained by the establishment of a heavy grass sod. Others are frost pockets in which tree seedlings cannot become established. Many openings are heavily used, although they may not be the best suited for the game species. When this study is completed next year, efforts will be directed toward finding methods for the establishment of effective permanent openings.

#### **Other Activities and Future Plans**

In cooperation with the University of Minnesota, the Lake States Station sponsored in August a workshop on ruffed grouse behavior and habitat.

Both land managers and research workers attended. Workshop participants agreed that grouse have definite traditional patterns which influence feasibility of intensive management. Birds tend to use particular areas, despite changes in forest type, and an area with a past history of grouse use has a better chance for management than an area without such use.

Other work in progress is concerned with development of efficient methods of vegetation sampling and of determination of relationships between browse production and other factors influencing plant development.

Future plans include work on deeryard rehabilitation and on fundamental problems of life histories of browse plants and of plants producing mast, berries, and catkins for grouse and other wildlife.



# Forest Diseases, Fire, and Insects

## DISEASES OF ASPEN

Gerald W. Anderson, Project Leader  
St. Paul, Minnesota

### Hypoxylon Canker Research Emphasized

Aspen disease investigations have continued at the Station with primary emphasis on hypoxylon canker. This disease remains the single most important killing disease of aspen. It attacks trees of all ages but is more prevalent on younger age classes. When older trees are infected, the cankers are usually on the upper stem or branches. There is no correlation between incidence and tree vigor, but the level of infection varies with different geographic locations. In the Lake States, northern Minnesota has the least amount of infection, while the Upper Peninsula of Michigan and parts of Wisconsin have the most. The canker population is cyclic. In Minnesota we are presently at a low point of new infections. During the remeasurement of 70 permanent sample plots this year, most of the cankers found were 3 or more years old. As a result of information now available it is believed that this may be the result of unfavorable environmental conditions for the disease in recent years, which limited canker establishment, development, or both.

We do not know how hypoxylon infects aspen trees. Attempts to inoculate trees have not been successful, except under conditions too artificial to resemble what might happen in nature. If we knew how the fungus is disseminated and becomes established, we might be able to minimize the effects of hypoxylon canker through manipulation of stand conditions. This lack of knowledge about the infection process indicates a need for more basic research on this disease (fig. 27). Plans are underway to initiate such research at an early date.

The University of Minnesota and the Station are conducting a cooperative study of the biology of the hypoxylon canker fungus. Progress has been made regarding spore liberation and some factors that may affect survival. Still unanswered, however, is the question of how the fungus causes infection in nature.

Dr. Ralph L. Anderson presented a summary of our hypoxylon canker research effort as part of a symposium at the annual meeting of the American Phytopathological Society at Amherst, Mass., in August. The text of his presentation will be published in *Phytopathology* in the near future.

### Heart Rot Attacks the Most Valuable Trees

In addition to hypoxylon canker there are a number of other aspen diseases that merit attention. One of the most important of these is heart rot, which continues to be responsible for the greatest volume losses in our aspen stands (fig.



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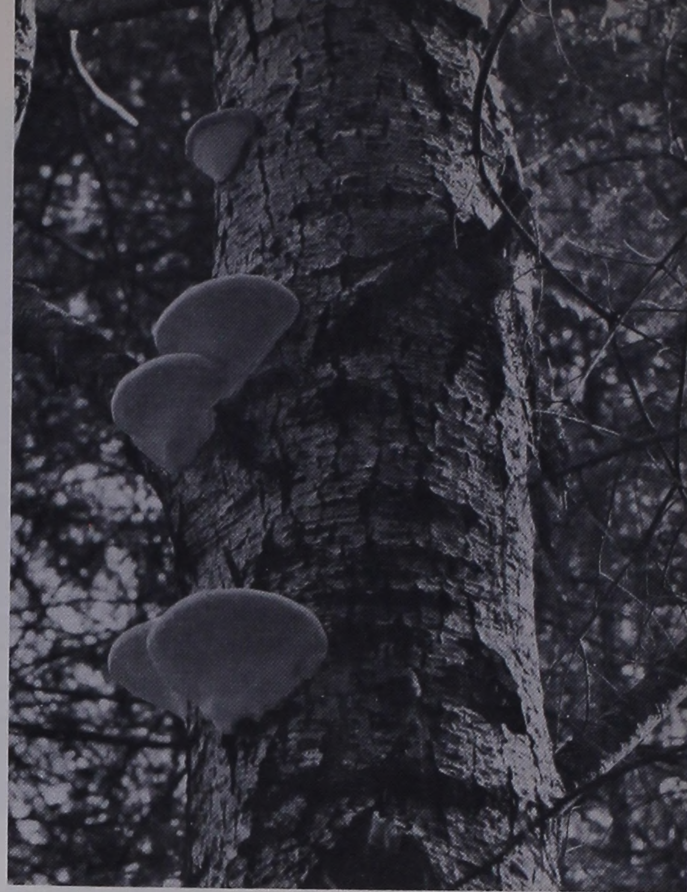
FIGURE 27. — Laboratory technician checks the color differentiation of tissues within a section of hypoxylon-infected aspen wood.



28). This is particularly disturbing because the affected trees are usually the largest and thus the most valuable. If not harvested before their pathological rotation age, entire stands may be rendered unmerchantable by these fungi. Not only does this represent the initial loss of volume on the area, but also it will delay the establishment of another stand if these cull trees are not removed. While we are aware of this decay and heart-rot problem and the need for a research program, we are not able to deal with it at present. This is one of our high-priority problems that will receive attention when staffing permits.

F-506079

FIGURE 28. — The mature aspen above is infected by a heart-rotting fungus that is fruiting on the bole. Trees so infected are culls. More research is necessary to determine the best management practices for minimizing these losses.



## DISEASES OF NORTHERN CONIFERS

E. P. Van Arsdel, Project Leader  
St. Paul, Minnesota

### White Pine Blister Rust

During 1963 we continued to place emphasis on white pine blister rust. Certain results obtained through these studies will eventually be applied to other diseases. In our blister rust work we try to make sure that all productive lines of research are being followed somewhere in the Lake States. These studies include eradication of cankers, genetic studies, and microclimate studies. A summary of our progress in each of these categories follows:

*Blister-rust-resistant white pine trees.* — The breeding and selecting of rust-resistant white pine trees is being carried out by the University of Wisconsin. The Lake States Station cooperates with the University in the establishment and maintenance of some test plantings. The program for the selection and breeding of resistant trees at the University of Wisconsin has been productive. This work could profitably be accelerated through increased financial support.

*Races of the blister rust fungus.* — We are continuing our studies to determine if there are

different forms of the blister rust fungus. If so, one form might prove able to infect pines that are resistant to a more common form of the fungus. This program seemed relatively simple at its inception, but serious complicating factors are involved (fig. 29.) Our research is necessarily being changed to more basic studies of the life cycle of the fungus to determine whether or not rust forms occur that can infect trees resistant to ordinary rust.

*Eradicating blister rust cankers by pruning and with chemicals.* — Recent tests made by Ray Weber have shown that pruning all low branches from young white pines every 2 years for the first 8 years after planting reduced fatal blister rust infections from 59 percent on unpruned trees to 19 percent on the pruned trees in north central Wisconsin.

Antibiotic fungicides are being tested as canker eradicators in several large-scale and detailed tests by Dr. Robert Phelps and Ray Weber. These tests were begun in 1962. It is still too early to draw definite conclusions.





F-506146  
 FIGURE 29. — Darroll D. Skilling lifts single sporidium from a teliospore of the white pine blister rust fungus with a micromanipulator. The single sporidia are inoculated onto white pine seedlings to determine the genetic variability between spores.

Some preliminary tests were established in cooperation with the University and State of Wisconsin in 1959 and 1960. These and other older tests do give some preliminary data. Only directly treated cankers change in appearance. Treated cankers that show chemical effects the first year might not show them the second.

*Microclimate studies.* — This work has improved, and helped to cut the cost of, control measures in some areas so that control effort can be concentrated where there is greater need. Station Paper 92 shows results immediately useful in blister rust control.

A new phase of research in airborne fungus epidemiology has been opened by the implication of certain night breezes as carriers of the pine-infecting spores. These 2-mile-per-hour breezes develop as a result of the differences between the water temperature of Lakes Michigan and Superior and the land temperature on the 40-mile-wide strip of land between them. The study area was a part of Michigan's Upper Peninsula.

As the land gets cold at night, adjacent cooled air moves in a low, cold flow out over the warmer lake. Spores released on currant bushes less than

5 miles from the lake are usually carried out over the water by this breeze; thus pines near the lakes are seldom infected. Above this cold flow a reverse flow carries the warmer lake air back over the land. Other more local warm spots, such as over swamps, forests, and small lakes, loft some of the spores to this backflow level. The backflow carries these spores to a strip 8 to 15 miles from the lake, where they are carried down by a downdraft. These spores infect pines both high in the crowns and as much as 5 miles from the nearest currant bushes.

While we haven't traced the spores all the way along this path, we have watched the lake breeze carry smoke and balloons along the way (fig. 30). We know the spores have 5 hours to move (before light kills them) in a breeze of 2 miles per hour, so they can go 10 miles. This movement just fits the pattern of rust infections we can see on the pines that has occurred in the past 20 years.

#### Western Gall Rust Discovered in Lake States

Dr. Gerald Anderson has found that western gall rust is present in Minnesota, Wisconsin, and Michigan. It has probably been here for many years but was confused with eastern gall rust.





F-506317  
FIGURE 30. — A smoke cloud exhibits layered land-to-lake flow 4 miles from Lake Michigan. Small balloons on streamers from the main balloon line showed a calm near the earth, a south breeze at 15 feet, and a north breeze above 20 feet.

Both rusts stimulate the pine host to produce similar globose galls.

This discovery brings to five the number of jack pine stem rusts in the Lake States. The three not mentioned above are: sweetfern, comandra, and stalactiform. Sweetfern rust is perhaps the most damaging of all five. In certain areas its spread seems limited, but some stands are 40-percent infected. This rust causes stem malformations that hamper bark removal and provide entrance courts for heart-rot fungi.

#### **Coleosporium Needle Rust Work Is Productive**

Coleosporium needle rust of red and other hard pines is a major problem in Christmas tree plantations. It frequently destroys all but the current year's needles. Thomas Nicholls, working jointly for the Lake States Station and the University of Wisconsin, has carried out most of our research on this disease.

A rather small amount of effort on Coleosporium research has produced considerable knowledge of the life cycle, the host range, and the effects of

temperature and moisture on spore germination and production. This new knowledge, when combined with that on microclimate gained in blister rust research, should give a quick idea of when and where the disease can be important.

#### **Other Important Plantation Diseases**

Plantations are becoming more and more important in Lake States forestry, but their diseases are receiving scant attention. Two needing work are "Jones' disease," a red pine plantation disease of unknown cause that is under surveillance, and a disease of eastern white pine, which is characterized by a brown circular sunken canker. Fruiting bodies of a fungus, *Phomopsis* sp., have been identified on the cankers (fig. 31), but pathogenicity of the isolated fungus has not been demonstrated.

No adequate assessment has been made of conifer plantation diseases. There may be potentially serious diseases that have not been recognized. Plantation root rots are threatening; *Armillaria mellea* is known to be present in damaging



quantities, and *Fomes annosus* may be present but not yet detected. The root rots, the Jones' Disease, and *Phomopsis* (?) canker are some we recognize. At present the Lake States Station does not have the necessary resources for investigation of these potentially important problems.

F-506318

FIGURE 31. — Examining white pines infected with a canker, probably *Phomopsis*, in Michigan. Spar Sager (right) found the cankers being examined by Dr. Van Arsdel.



## DISEASES OF NORTHERN HARDWOODS

John Ohman, Project Leader  
Marquette, Michigan

### Sugar Maple Defect Indicator Discovered

A useful external indicator of interior defect in sugar maple has been discovered. We have noticed that the bark of some sugar maples is sooty black, in sharp contrast to the normal grey. Investigations have shown that the black-barked trees have been heavily and repeatedly attacked by sapsuckers. Sapsucker wounds and their associated stains cause considerable degrade in logs and the lumber sawn from them (figs. 32 and 33).

Observations indicate that heavy sapsucker attacks are concentrated almost exclusively on these black-barked individuals. Black-barked trees of all size classes, from saplings up, have been observed, and show some evidence of annual sapsucker attack for 125 years or more. We are now trying to determine why these trees are so attractive to sapsuckers. We first thought that high concentrations of sugar in the sap of certain trees might be attracting the birds. However, preliminary analyses of sap collected during the

spring of 1963 indicated that this was not true.

The reason for the sooty appearance of the bark illustrates an interesting biological relationship. Wounds made in early spring by the sapsuckers release large quantities of sap having a high sugar content. The bark below such wounds becomes soaked with sap and, after evaporation, has a relatively high sugar content. This bark provides an ideal food base for a dark-colored fungus, tentatively identified as *Capnodium* sp., which gives the bark its sooty black appearance. Thus, the saprophytic growth of a fungus, which apparently is in no way responsible for the bird peck defect, serves as an indicator of the defect in standing trees.

Small circular wounds in the bark arranged in horizontal rows are also present on such trees but are rather inconspicuous and easily overlooked when trees are marked for improvement cuttings. By using the very obvious black bark indicator, the land manager can identify sapsucker-damaged





F-506113

FIGURE 32. — Dr. Ohman uses a power plane to smooth sugar maple sections containing bird peck defect. He will later examine the defects (black spots in growth ring area) under magnification.

sugar maples early and have them removed. This will allow him to concentrate his forest's growth on higher value trees.

### Logging Damage Studied

A study of logging damage caused by various types of skidding equipment was made in cooperation with the Marathon Division of American Can Company. Three 40-acre blocks of northern hardwoods were cut selectively, and skidding was done differently on each. On one a small crawler tractor skidded log-length loads. On the second a large rubber-tired, four-wheel-drive, four-wheel-steer skidder removed log-length loads. The same rubber-tired skidder was used on the third block, too, pulling treelength loads. Preliminary results indicate that damage was not excessive in any block. However, the large rubber-tired skidders and larger loads caused more damage than the smaller crawler unit and loads.

### Two Sapstreak Studies Underway

Two major studies on sapstreak of sugar maple were started. In one the effects of various stocking

levels and cutting cycles on incidence of the disease will be evaluated annually for several years. Preliminary observations indicate that losses are greatest in stands that are heavily cut on a short cycle. The other study is designed to provide information on the effects of season of wounding, age of wound, and time of inoculation. It, too, will continue for several years.

In addition, a limited exploratory study of possible vectors of the sapstreak fungus was started and will be expanded next year.

### Research on Dieback Relationships Continues

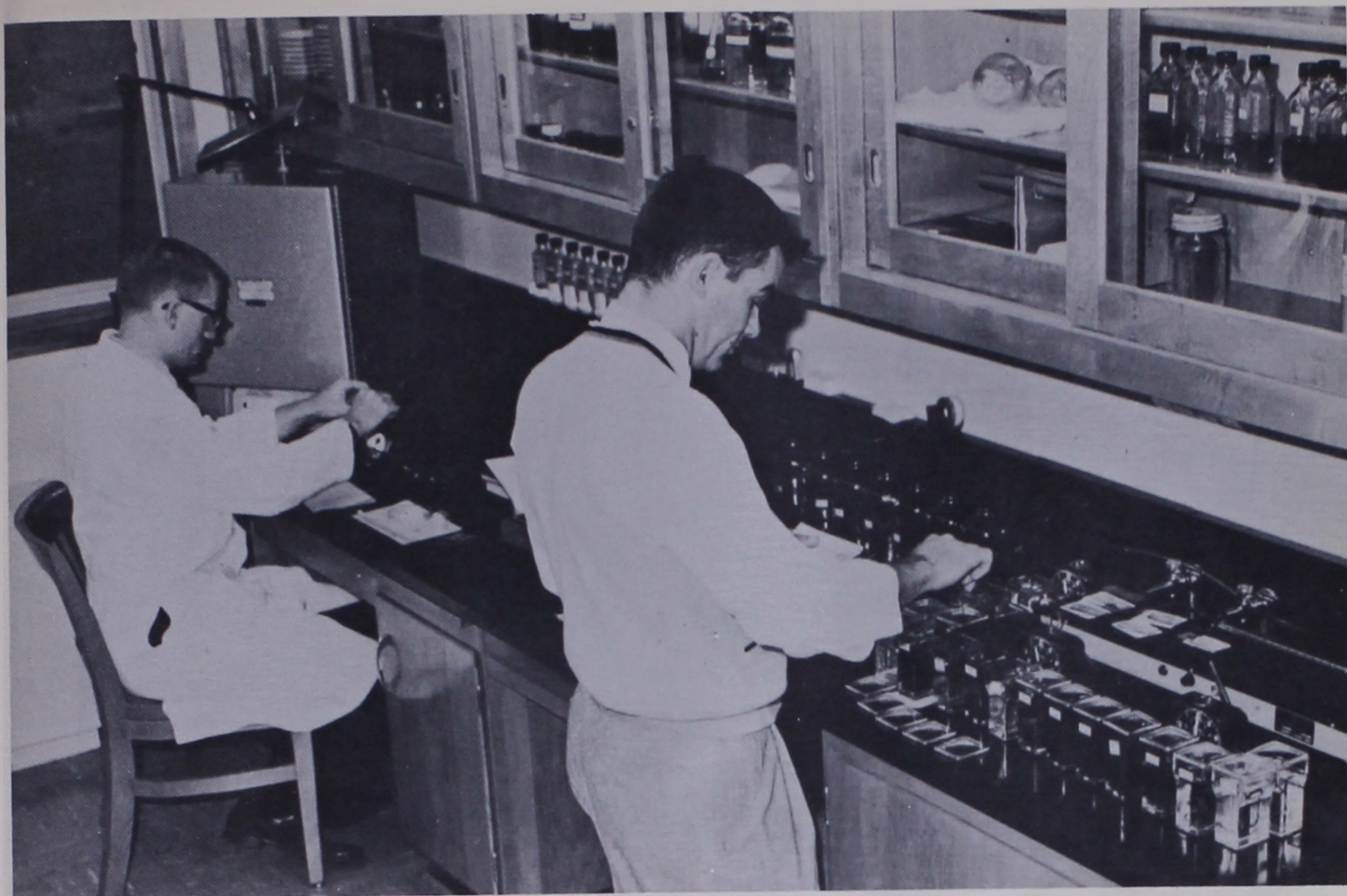
Work is proceeding on several aspects of the dieback problem. As observational evidence accumulates, it becomes more apparent that dieback is a problem with a single noticeable symptom — death of a portion of the crown — apparently caused by a number of agents that may interact to lessen or increase severity. Some causal agents, such as porcupine and sapsucker girdling in the crowns, are obvious. These act directly and need little research effort. Other agents, such as soil moisture, compaction, weather, and pathogens, are often obscure and may interact with each other. These require a great deal of research effort.

Two major studies are now underway. In one, an old-growth northern hardwood stand has been instrumented with soil moisture and temperature measuring devices. These will measure the effects of cutting and skidding, separately and in combination, to see how they relate to soil moisture, temperature, compaction, and, ultimately, dieback.

The other will test the effects of high water tables in spring and early summer to determine how they are related to dieback. Earthen dikes have been constructed around small plots containing various northern hardwoods. Upslope, a stream has been impounded. From the impoundment, water will be supplied to individual plots through a system of large-diameter irrigation pipe. Plots will be flooded for varying periods from spring breakup through June during the coming growing season.

Analysis was completed on the first 5 years (1958-1962) of a large-scale study of dieback in a northern hardwood stand. This is part of a forest management study of growing stock levels and cutting cycles. Over 2,000 trees were evaluated annually. Dieback increased each year, with most of the increases in the larger size classes. The





F-506112

FIGURE 33. — Dr. Kenneth Kessler operates the microtome in the pathology laboratory at the Northern Hardwoods Laboratory, while Richard Blank stains microscopic sections.

damage was greatest in heavily cut stands. About 50 percent of the 15"+ d.b.h. trees showed symptoms, while only 7 percent of the 5-9" d.b.h.

trees were affected. Nearly all affected trees had less than 50 percent of the crown involved, and less than 1 percent have died since 1958.

## FIRE CONTROL SYSTEMS

**John H. Dieterich, Project Leader**  
**St. Paul, Minnesota**

A subtle but important change in forest fire conditions is taking place in the Lake States. This change, related directly to the increased volume and concentration of natural fuels in nearly all wild land cover types, has come about slowly. It has been developing as a result of three land management practices. These are: (1) more adequate fire protection, (2) increased timber cutting, and (3) increased planting.

How do these factors contribute to an ever-increasing complex of natural fuels? First of all, better fire control practices reduce the overall area burned, as well as the area burned on individ-

ual fires, and bring about a larger accumulation of fuel in nearly every fuel type. Increased cutting of timber and pulp results in more areas of slash fuel and logging debris — one of the most critical fuel types recognized by fire control agencies.

And, finally, pine plantations amounting to more than 3 million acres have been established in the Lake States. More land is being planted each year. Not only is there an increase in the amount of available fuel from new plantings and the growth of old ones, but also during dry weather a large percentage of this fuel becomes readily



F-506143  
 FIGURE 34. — The crown fire continues to cause severe damage in isolated pine stands. The needles on the crowns and the surface litter combined to make approximately 14,000 pounds or 7 tons of fuel per acre available in this fire.



flammable. Fires in such fuels often become crown fires, the most difficult problem faced by the fire control agencies (fig. 34).

Current and future fire research will be directed toward gaining a better understanding of some of these fuel and weather situations so that a more adequate level of fire preparedness can be realized.

#### **Crown-Weight Determinations**

This continuing study is designed to provide fuel information for various timber stands and to determine the effects of these fuels on fire behavior and intensity. Research Note LS-19, by James K. Brown, summarizes the amounts of crown fuel in red pine plantations. During the past year similar data have been collected that will permit a parallel analysis in jack pine plantations — also important from the fire and management standpoint.

Preliminary inspection indicates that jack pine has less needle material than red pine for a given size tree, and the effects of site and stand density on tree crown weights may be less pronounced.

#### **Moisture Content of Live Crowns**

For the past two years we have been periodically measuring moisture content of the live crowns in red pine plantations on both good and poor sites. Moisture differences due to site appear to be small, but seasonal changes indicate that there is good basis for the feeling that plantations may be more susceptible to crown fires in the spring. The lowest average moisture contents occur in the spring before any new growth has started, and the highest are found in late summer when all new growth has developed.

#### **Litter Fuel Measurements — Weight and Moisture Content**

Litter fuels are an important component of the overall fuel complex in all forest types, particularly the conifers. Fires will spread or go out in litter, depending upon the amount available to burn and its moisture content. Research Note LS-14 summarizes the work that has been completed to date in measuring and estimating litter fuels in red pine plantations.



An additional study concerning the effects of weather variables on moisture content of forest floor fuels has provided a basis from which to assess burning conditions. The moisture content of litter fuel correlates well with a computed, daily Buildup Index, which is an integral part in the new Unified National System of Fire Danger Rating. The Buildup Index is, in effect, an indicator of moisture deficiencies in surface fuels and small branchwood. It can be used as such to predict fire persistence and difficulty of control, and as a better indicator of when to use prescribed fire to accomplish specific objectives (fig. 35).

### Assistance in Prescribed Burning Work

The fire research program has no active studies underway involving prescribed burning. It has, though, provided technical assistance to both State and Federal forestry agencies in planning and carrying out several prescribed burning operations. During the past year we provided technical assistance to other research projects dealing with prescribed burns in relation to hazard reduction, type conversion, site preparation, and wildlife habitat improvement.

### Slash Deterioration

There seems to be little or no agreement concerning the effects of aging on slash hazard and flammability. From the standpoint of fire protec-

tion costs, it is important to know the decomposition rates of slash from various commercial species. A study has been established to identify some of the differences due to physical and chemical change and the resulting change in heat content of the combustible material.



F-506142  
FIGURE 35. — Changes in moisture content of surface fuels are being studied to better understand ignition, fire spread, and fire effects. The amount of available surface fuel also has a direct bearing on fire persistence and control.

## DEFOLIATOR INSECTS

Harold O. Batzer, Project Leader  
St. Paul, Minnesota

### Spruce Budworm Damage Reduced in Mixed Stands

Final observations have been taken on most of the spruce budworm studies, and the data for these are undergoing analyses. The risk evaluation studies show that stand composition markedly influences the amount of damage by the budworm. Spruce and fir that are shaded by overstory non-host trees experience only slight damage, while those growing in the open, only a few yards away, undergo severe damage (fig. 36). This suggests that spruce budworm damage within a stand should decrease as the percentage of nonhost trees increases. We have developed an equation that shows an inverse relationship between dead or

severely damaged spruce-fir and the nonhost species component (aspen, birch and pine) in spruce-fir stands. This phenomenon, still undergoing critical analyses, may lead to a technique that can be used to reduce damage from budworm outbreaks. The results will be incorporated into management recommendations for the spruce-fir type.

It has been suspected for many years that the incidence of staminate flowers in balsam fir stands might be a key factor in predicting damage to balsam stands. We have found that this is not true. Although the budworm larvae feed on staminate flowers and hibernate largely in the flower bracts, this relationship is of little value in predicting damage to trees during epidemics.





FIGURE 36. — Balsam firs growing beneath overstory nonhost trees escape damage by the spruce budworm while those growing in the open only a few yards away are killed.

F-506322

### Spruce Budworm Outbreak Is Reduced in 1963

The spruce budworm infestation in northeastern Minnesota showed a decline in 1963. The Station cooperated in an aerial survey with personnel from the Beltsville Forest Insect Laboratory, Region 9 Pest Control Section, and the Minnesota Bureau of Plant Industry. Table 4 shows the acreages found in the various infestation categories. For the first time, estimates of tree mortality were also made. The survey used the operations recorder technique developed by the Beltsville Forest Insect Laboratory.

Although the infestation area is reduced, egg collections indicate that noticeable defoliation may be expected in 1964 over much of the infestation area.

### Young Balsam Fir Withstands Defoliation Best

Sapling-sized vigorous balsam fir trees withstand spruce budworm defoliation better than mature trees. Studies on the responses of young trees to defoliation showed that the defoliated branches exhibit a proliferation of new shoots following heavy defoliation. These shoots are for the most part adventitious, and only a few originate from dormant axillary buds (fig. 37). Older, mature trees produce few such shoots after defoliation. This makes older trees more vulnerable to damage by the spruce budworm and, in part, explains why young, vigorous stands are able to survive heavy attacks.

TABLE 4. — Spruce budworm damage survey in northeastern Minnesota, 1963 as compared with 1961<sup>1</sup>

Damage category	1961	1963
	<i>Acres of type</i>	
Moderate to heavy current defoliation	366,300	130,600
Severe defoliation	240,800	116,200
20-50 percent mortality of spruce-fir	( <sup>2</sup> )	112,200
51-100 percent mortality of spruce-fir	( <sup>2</sup> )	130,700

<sup>1</sup> No survey was made in 1962, hence 1961 acreages are given for comparison.

<sup>2</sup> This information obtained for the first time in 1963.



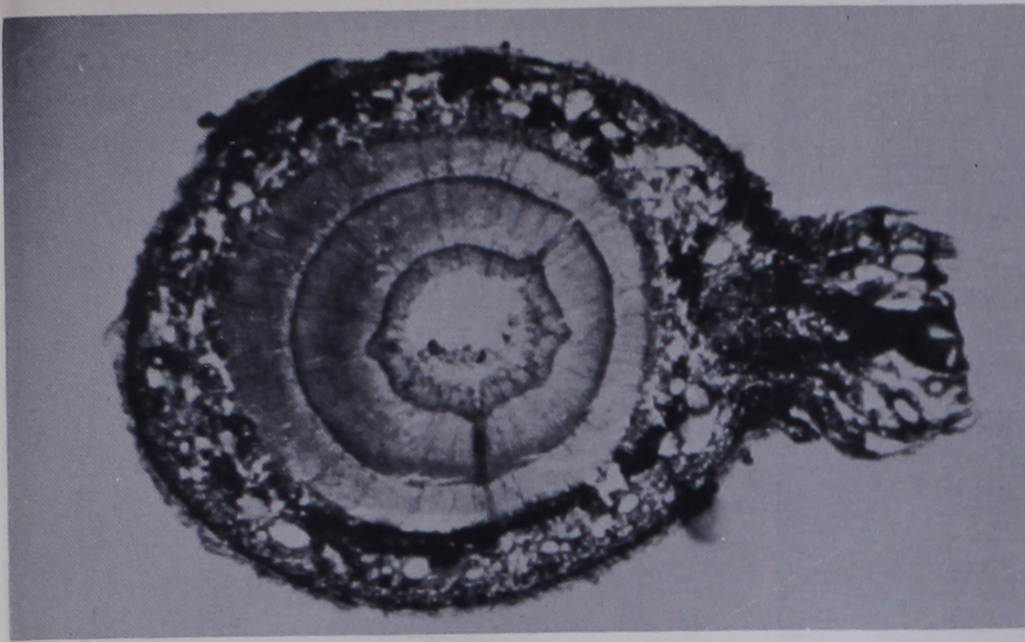


FIGURE 37. — Cross section of a 2-year-old balsam twig shows the adventitious bud produced after spruce budworm defoliation. Had this bud been of dormant axillary origin, a branch trace (vascular connection with the pith) would be evident.

## PLANTATION INSECTS

William E. Miller, Project Leader  
East Lansing, Michigan

Nearly one-fifth of the plantation acreage has suffered serious damage due almost entirely to insects, according to recent surveys in northern Lower Michigan. Projected to the Lake States as a whole, these findings indicate that losses are enormous. The plantation insect project has shifted into high gear, undertaking a broad front of new studies to supply land managers and tree growers with accurate and rapid appraisal techniques, emergency "blitz" suppression measures, and cultural and biological control techniques.

### Snow-Depth Pruning Inhibits Shoot Moth

Soon to be published are the results of several years' investigations dealing with the European pine shoot moth. We have found that a cultural measure, "snow-depth pruning" (fig. 38), will significantly lower the population trend from one generation to the next. Winter mortality and site quality are the two important factors in the damage potential of the pest. Sites promoting vigorous tree growth strongly moderate the insects' immediate and residual damage, while the degree of winter mortality directly influences population growth or decline in succeeding generations.

Snow-depth pruning promotes the insect's winter mortality. In young plantations, many infested tips on low branches may be covered completely

or partially by snow during the winter. This insulates overwintering larvae from killing winter temperature combinations. These larvae become the procreators of a higher population the next generation. Pruning off branches likely to be covered by snow removes this refuge, increasing the insects' winter mortality and reversing upward population trends.

### New Pine Root Collar Weevil Control Needed

The pine root collar weevil poses one of the more alarming current problems in plantations. Favoring several species of conifers, it feeds at the root collar, causing growth loss and eventual death. Current control of the insect with chlordane is considered too expensive. A comprehensive study of this insect, especially its population dynamics, was begun during the year to find a cheaper, more effective method of control.

Progress has already been made toward correlating population levels and resulting host damage. Such a correlation shows that treatment is necessary before tree damage symptoms become obvious. For example, a young red pine plantation with an average of five insects per tree usually has an average of about 60 percent girdling per tree (ranging, among individuals, from zero to 100 percent). At this level of infestation, height growth





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 FIGURE 38. — This red pine (left) had its lower branches embedded in snow during winter, protecting shoot moth larvae from winter mortality. Dotted lines indicate positions of limbs and stem under snow cover. The next summer, branches were pruned off the lower 2½ feet of that tree's stem (right), eliminating the insects' protective winter cover.

loss amounts to about 8 percent, and about 2 percent of the trees are dead or dying. Individual dead trees always have 85 percent or more of the stem circumference girdled. Sometimes these trees retain their green color for awhile. Even population levels of less than the five larvae per tree in this example are critical; yet they may go undetected while building up to higher levels.

## SEED AND CONE, SHELTERBELT, AND ASPEN INSECTS

Harold O. Batzer, Acting Project Leader  
 St. Paul, Minnesota

### Cone Insects Stressed

With the establishment of seed-production areas, attention has been focused on producing good and abundant seed for reforestation. Yet surveys of cone crops from these areas indicate that insects continue to exact a heavy toll on cones of red pine and white spruce. Red pine cones collected on National Forest lands throughout the Lake States show a high degree of infestation (fig. 39).

The study has confirmed that practically no parasites and predators affect this weevil. We do not yet know what factors keep this pest from multiplying indefinitely in plantations, or how these factors can be intensified to achieve lasting, natural control. Some plantations appear to be immune to the pest. Whether this immunity is genuine or accidental will be investigated. If genuine, it could provide leads for preventing future pine root collar weevil infestations.

### New Survey Methods Being Developed

The program to develop rapid methods for appraising plantation insect pest situations will eventually give the manager tools for obtaining the advance information necessary for pest control action. New survey methods have been developed for pine root collar weevil and European pine sawfly.

These methods relate the proportion of units infested in a sample (which can be rapidly determined) to the absolute population level (the important factor, which is difficult to determine directly). Each such relationship for plantation pests is unique. For example, a population of three pine root collar weevil larvae per tree indicates a plantation infestation of 80 percent, while 80-percent infestation with European pine sawfly is indicated by a population of about four larval colonies per tree. These relationships hold for trees from 2 to 12 feet tall.

The red pine cone beetle, *Conophthorus resinosae*, still appears to be causing the most damage on red pine. The spruce seedworm, *Laspeyresia youngana*, was responsible for damage to 60 percent of the infested white spruce cones.

Studies are underway to determine how cones and insects are normally distributed on trees. This will help develop sound methods of sampling and control. Observations on young, open-grown red pine trees in 1962 showed a definite correlation



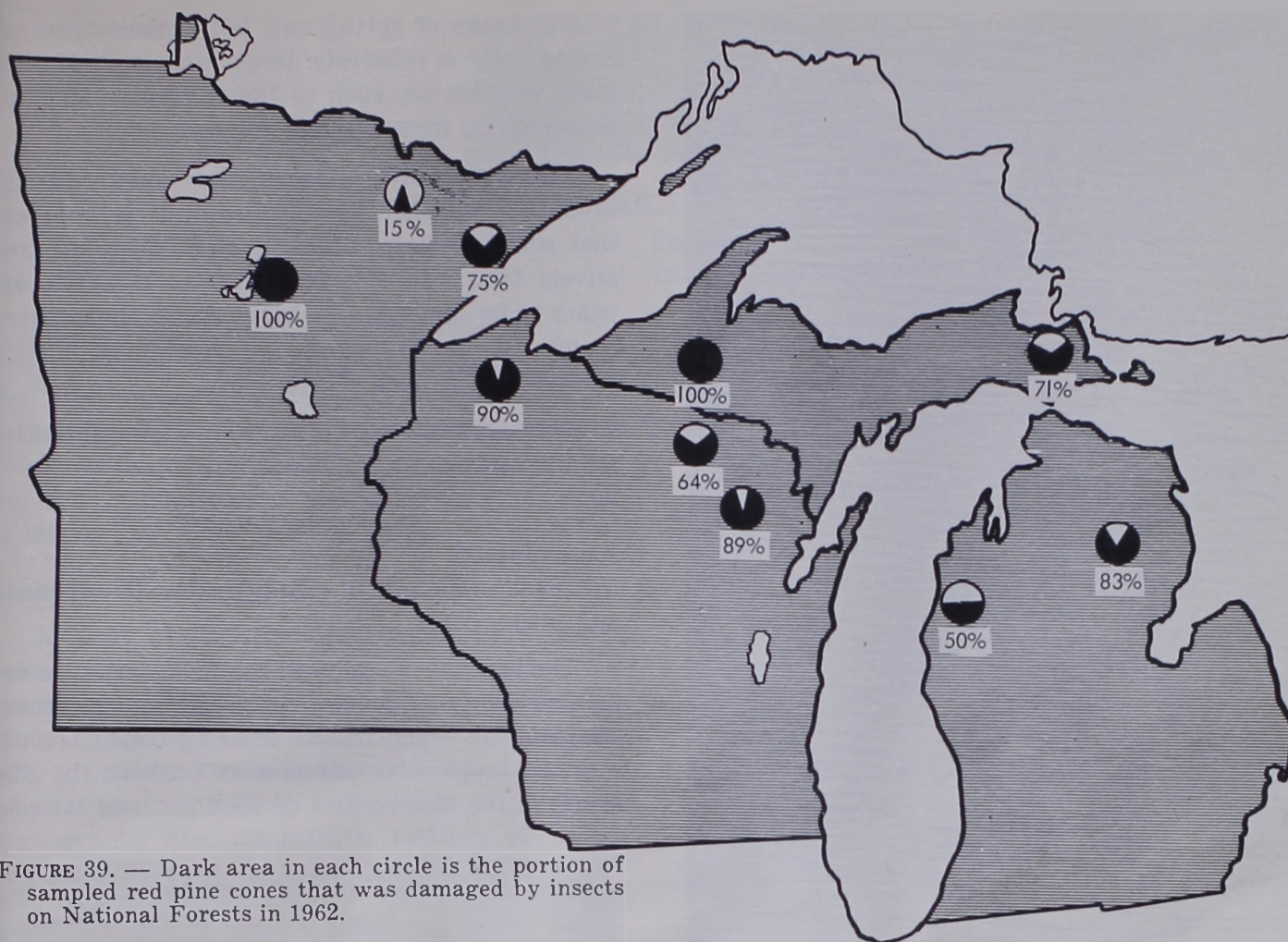


FIGURE 39. — Dark area in each circle is the portion of sampled red pine cones that was damaged by insects on National Forests in 1962.

between cone production and branch size times branch height in the crown. This year, sampling of older trees growing in closed stands and in clearings showed the same relationship.

Other information, though limited, suggests that the vertical distribution of red pine cones in individual trees is followed closely by the vertical distribution of at least two cone insect species, *Conophthorus resinosae* and *Rubsaamenia* sp. Tubular steel scaffolding has been erected around two red pine trees, to provide stable observation platforms where detailed measurements and observations of cone insects can be made.

White spruce cones are usually confined to a narrow band in the crown. However, sampling has revealed a definite horizontal pattern of insect distribution. The outside cones are not attacked by the spruce seedworm as frequently as cones inside the crown. Conversely, cone length and number of contained seeds decrease from the outer to the inner part of the crown. This information has

practical significance for seed and cone collectors.

Observations on insect life histories indicate some possible areas for cultural control. A total of 1,228 white spruce cones of the 1962 crop were collected from the ground in four areas known to be infested by the spruce seedworm. One-third of the infested cones contained live larvae in a state of extended diapause. This may be an evolved safety factor that enables the species to survive a period when its food supply is limited or non-existent. Equally important, if these cones are destroyed, the larvae, which would otherwise attack the new crop, will be destroyed.

#### Shelterbelt Insects

Shelterbelts in the Northern Great Plains have been established under adverse climatic and edaphic conditions. Because of this, it has long been suspected that insects are a factor in establishment, survival, and growth of these belts. To determine whether or not this is true, a study of the





F-500795

FIGURE 40. — Chokecherry planted in shelterbelts seems to be preferred by defoliating insects, such as the fall webworm.

abundance of shelterbelt insects in North Dakota was initiated this season. One phase of this study is to determine whether populations of the various insect species differ by temperature and precipitation zones. Also, is the prevalence of insects related to tree species and age class? A secondary objective is to determine which insect species may have the greatest potential for damage over a period of several seasons.

Although the first year's data are still undergoing analysis, there is an indication of increasing insect damage by zones, from east to west. However, this might be confounded by an accompanying decline in tree vigor and species composition.

Outbreaks of spring and fall cankerworms occurred over a relatively large area in 1963. Primary woodborers, such as the oak borer and carpenterworm, were far less common.

Although many species of trees and shrubs are used in shelterbelt establishment, it is apparent that some species, such as Russian-olive, are relatively free from damage. Siberian elm, too, appears to be somewhat resistant, while chokecherry seems to be preferred by defoliating insects wherever it is planted (fig. 40).

Further analysis of the survey data will dictate the direction of new studies.

### Aspen Insects

(In cooperation with the Universities of Wisconsin and Michigan)

The aspens rank high in the Lake States, so far as merchantable volume of wood is concerned. Research on aspen insects is being conducted under two cooperative agreements between the Station and the Universities of Michigan and Wisconsin:

The life history and site relationships of two aspen borers are being studied by the University of Michigan through a cooperative-aid study. One interesting highlight of this research is that the larvae of one of the borers, *Saperda moesta*, hatching from eggs laid early in summer, are able to progress to adulthood in one year. Larvae hatched from eggs laid later spend 2 years in their galleries before emerging. Preliminary analysis has also shown that damage by another borer, *Oberea shaumii*, appears to increase in trees growing on poor sites.

The cooperative-aid study at the University of Wisconsin is concerned with degrade in hardwoods as a result of cambium mining of Agromyzids. These insects cause characteristic elongate or serpentine artifacts in veneer cut from infested trees and cause degrade that limits its use. Objectives are to develop knowledge on the life histories, ecologies, and populations of species in the genus *phytobia* which inhabit sugar maple.



# *Marketing, Engineering, Utilization, and Economics*

## **FOREST PRODUCTS MARKETING**

**Dean Quinney, Project Leader  
Duluth, Minnesota**

The Station's wood products marketing research project, located on the Duluth Campus of the University of Minnesota, completed data-gathering and much of the preliminary analysis of opportunities for expanding northeastern Minnesota's manufacturing and marketing of wood products.

### **Transportation Resources**

A study of transportation resources in northeastern Minnesota is nearly ready for review, and results should be published early in 1964. This study compares freight rates for nationwide shipping of selected forest products to important manufacturing and market centers. In addition to documenting the competitive position of northeastern Minnesota in these selected market centers, the study will present information on the available transportation facilities, including truck,

rail, and ship service. It will also categorize present forest product movements.

Duluth, a major transportation center, is an excellent outlet to national and international markets. The city is served by seven Class 1 line haul railroads, a situation that compares favorably with nearly any city in the country. Duluth is also directly linked to overseas commerce by the St. Lawrence Seaway (fig. 41). Although the potential of the outstanding port facilities has not yet been fully realized, early reports indicate that both the number of sailings and volume of cargo shipped in 1963 increased substantially over that recorded in previous years. Trucking facilities are also good and eight interstate common carrier lines have terminals in Duluth. In addition, several feeder lines serve the entire area daily. The Federal and State primary highway system is adequate, with particularly good connections to the south and east. Upon completion of Interstate Route 35, Duluth will be directly linked with the national superhighway system.

FIGURE 41. — Duluth, Minn., is one of several port cities in the northern Lake States which offer attractive opportunities for expanded manufacture of wood and wood-derived products.





One-line rail hauls for wood products are available from Duluth to Chicago, Terre Haute, St. Louis, Kansas City, Omaha, and all major cities in Wisconsin, North and South Dakota, Washington, and the northern parts of Idaho and Oregon. Thirteen trains leave Duluth daily for direct or connecting service. Direct truck hauls are made daily to Chicago, Cleveland, Detroit, Toledo, St. Louis, Kansas City, Des Moines, Omaha, and Denver.

While this study of transportation facilities and costs of shipping wood products deals primarily with the five northeastern counties of Minnesota, much of the information will have application to wood product shipping problems in other northern Lake States areas.

### **Sites for Water-Dependent Plants**

Water influences the location of many wood-using industries. In fact, it can be *the* limiting factor in site location for pulp, paper, or composition board mills. The pulp and paper industry, for example, needs water in variable quantities, depending upon the size of the mill, type of processing, and the degree of integration.

Thus, a study was made to evaluate potential sites with adequate water resources for new or expanded plants in the five counties of northeastern Minnesota. Sites were selected that had sufficient water of good quality to support a minimum economic size plant. A major assumption was that mills would practice a reasonable degree of waste treatment. Other factors influencing selections were transportation facilities, labor, utilities, land use restrictions, and possible conflicts with recreational activities. From study data, sites were considered on two lakes and seven rivers.

Lake Superior sites in the vicinity of Two Harbors or Duluth appear to be the best locations for mills. An outstanding feature of Lake Superior is the high-quality water along the North Shore.

The St. Croix River, near Pine City or Rush

City, is the only river location (not already intensively used) that has enough water to supply minimum economic size plants. This location is about 60 miles from the Twin Cities market area and closer to other large midwestern market centers than any other site considered. However, recreation along the river is important and increasing, as Minneapolis-St. Paul residents find the area appealing.

### **Other Endeavors**

Other material also is being analyzed for publication. This includes the location, volumes, and availability of the timber resource; additional site location factors; the relative opportunities in expanding markets for existing wood products; and the finding of markets for new products not now being manufactured in northeastern Minnesota. At the completion of these initial studies, similar analyses will be made for other selected forested areas of the northern Lake States.

The project staff participated in a nationwide study of wood products use for additions, alterations, repairs, and replacements in residential and commercial construction. Minneapolis was chosen as one of 10 cities canvassed to determine how much and what kinds of lumber, hardboard, particle board, etc., are being used, and to gain an insight into the market potential for wood products in this type of construction.

The marketing research staff has answered many calls for information and made numerous on-the-ground examinations in support of new or expanding wood-using plants. Increased timber supplies that are showing up in the current Minnesota Forest Survey and the activities of the Area Redevelopment Administration and Rural Areas Development have combined to stimulate new interest in wood products manufacture. The demand for market analysis has grown rapidly this past year. We anticipate a substantial increase in requests next year.



## FOREST ENGINEERING

Rulon B. Gardner, Project Leader  
Houghton, Michigan

A major problem under study is the present system for harvesting, handling, and transporting roundwood. Although mechanization has increased in recent years, there is considerable need for more research into the development of specialized equipment if the high cost of roundwood extraction is to be reduced.

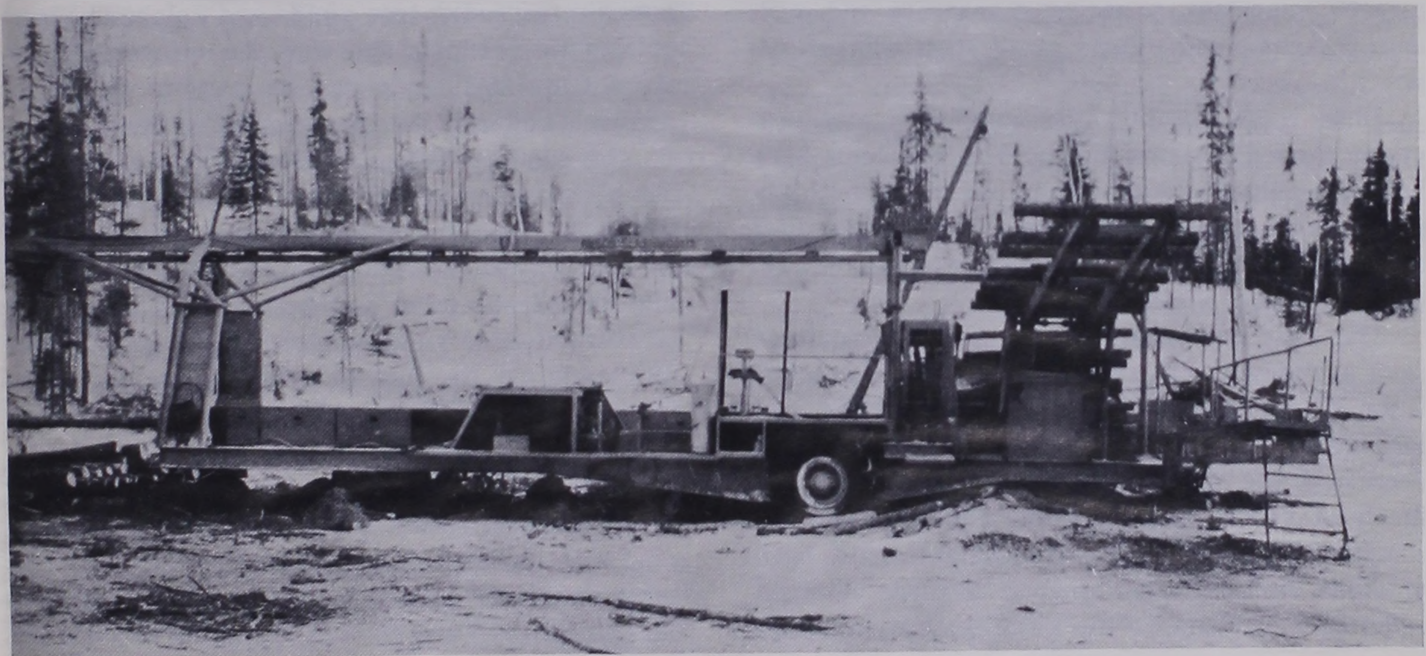
Repeated handling of low-value roundwood products is a major cost-increasing factor. Producers have recognized this, but very little research has been devoted to the problem. During recent years the emphasis has been put on mechanizing roundwood harvesting (fig. 42). However, mechanization in this phase of woods operations has nearly reached a plateau. Handling, beyond this point, still demands attention.

Several attempts have been made to chip roundwood in the field. These have been unsuccessful because suitable mobile processing equipment was not available. Still, this and other field processing methods show great promise for eventually reducing costs. This concept not only eliminates unnecessary handling of large volumes of waste material but also reduces the handling of usable raw material to a minimum. It requires mobile processing plants, and power requirements have always

limited the size and production capacity of the processors. If chips are to be made in the woods as near the source as possible, the power required to produce them must be reduced and an economical, low-weight-to-horsepower power supply must be developed.

The lack of information about the chipping process has made it desirable to carry out basic research on power requirements for chipping at different wood grain orientations. This information is essential if new processing equipment is to be developed. Figure 43 shows stages in the development of a machine that will help to determine power requirements needed for chipping wood. The machine is adjustable so that various combinations of grain and chipper knife angles can be tested. This experiment is being conducted as a cooperative project with the Mechanical Engineering Department of the Michigan Technological University. Although no results are yet available, considerable progress has been made in developing techniques. The results should provide some of the information needed for equipment design. In another part of the study, the physical properties that affect the handling and pulping of chips will be investigated.

F-504159  
FIGURE 42. — This slasher-loader converts tree-length boles into pulpwood bolts at the landing.





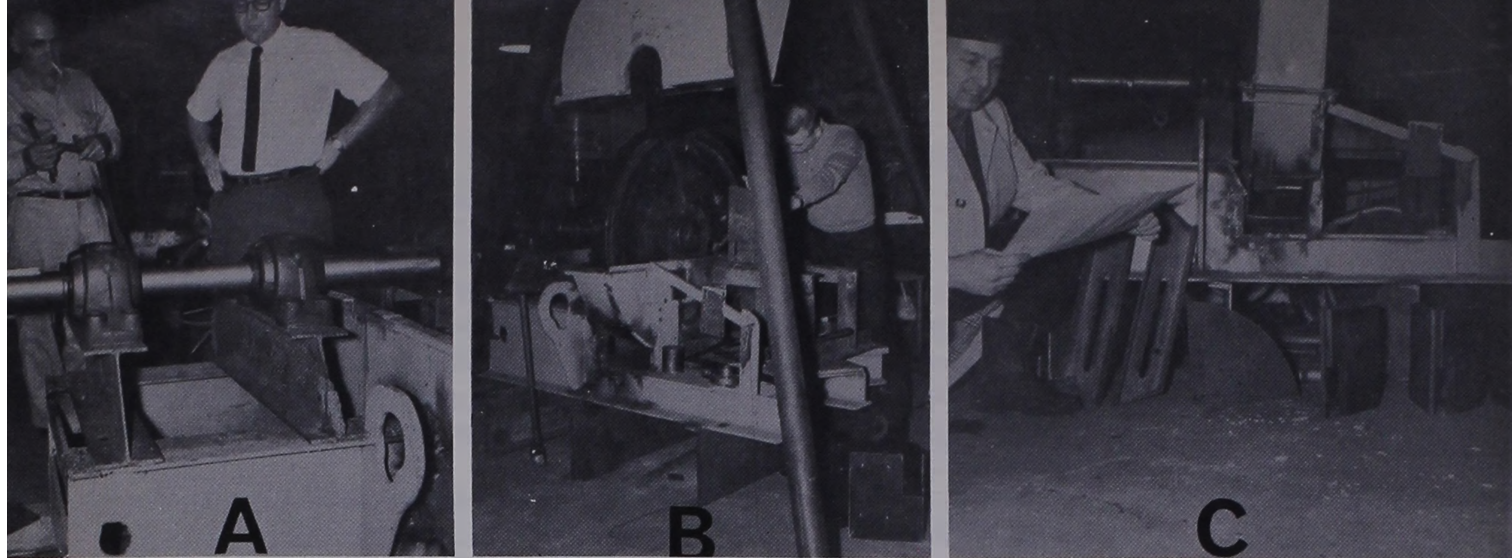


FIGURE 43. — Above are components of an experimental machine that is being developed to determine the power requirements that are necessary for chipping roundwood products. Illustrated are (A) a drive

shaft for strain gage mounting, (B) the basic unit assembly, and (C) part of the tooling that will control angle of wood grain material as it is fed into the machine.

F-506166-8

## TIMBER CHARACTERIZATION AND PROCESSING

Richard M. Marden, Project Leader  
Wausau, Wisconsin

### Evaluating Hardwood Tree Quality

Work has been continued on the tree quality study to develop a reliable and accurate sugar maple tree grading system. To accomplish this, we must relate tree characteristics to yields of specified products. Past grading systems for standing trees have used only one or two stem characteristics as indicators of quality. These attempts have been largely empirical. Their results were unsatisfactory because the combinations of stem characteristics affecting quality are nearly infinite and could not be considered. Each characteristic may be important, so we must measure and evaluate the combined effects of all stem characteristics.

Until quite recently the computers and programs needed to solve multivariate problems have been unavailable. In this study, we are using high-speed, large-capacity computers to find the best combinations of stem characteristics to use for predicting product yields.

The first attempts to find these combinations used as many as 25 expressions of stem characteristics. Good correlations resulted, but some factors contributed very little to the results. We next decreased the number of factors by eliminating the least useful ones from the equations. Recent computer runs with only seven characteristics have provided results nearly as good as those obtained when 25 were used. In the field application we in-

tend to use as few indicators as possible and still obtain the required performance.

Work is underway to locate a lower portion of the tree stem that can be used as an indicator section for determining total tree quality. This is necessary for practical field application of the tree grading system. Here again, the computer will make possible a task which, in the past, has been approached empirically. Figure 44 illustrates how the tree grading method might be used in the woods.

The results thus far show that it is definitely possible to predict tree yields and values in terms of specific products and that the information derived from this study can be used to devise an accurate and reliable tree grading system.

The grading system is necessary to aid in timber appraisal work, to judge the effects of stand treatment upon the quality of growing stock, and to help determine when a tree will provide its highest market value and best use. This accurate measurement of yield and control of quality may ultimately be the key to profit in timber growing, processing, and marketing.

### Bolter Mill Investigations

A cooperative-aid study was completed this year with the University of Michigan. It dealt with some economic aspects of bolter mill<sup>2</sup> operation. The objectives were twofold: First, an exploratory



study was made to determine the costs of converting hardwood timber into both top-grade logs and bolts, as compared to the cost of simply removing the saw logs alone. Second, the complete operation was analyzed to determine relative costs and returns in an operation where logs and bolts were removed from the cutting area and processed, respectively, in a circular sawmill and a short log bolter. The circular mill produced 1-inch lumber, while the bolter produced dimension stock.

The white, red and black oak trees were selectively logged on a typical farm woodlot in southeastern Lower Michigan. All Grade 1 and Grade 2<sup>3</sup> material was bucked into saw logs. All Grade 3 material was carefully inspected and very often bucked into bolts, instead of logs. Totals of 6,010 board feet of saw logs and 1,632 board feet of bolts were taken from the 2.9-acre study area. Bucking for bolts as well as saw logs resulted in the recovery of 26 percent more volume than was shown by the cruise.

Because the smaller Grade 3 logs were bucked into bolts, the average sawmill log was of better quality and considerably larger. This increased the efficiency of the sawmill operation. Expansion of the results obtained from this small plot indicates that the daily lumber production of the standard log sawmill would be increased by 1,000 board feet and, in addition, the bolter mill would produce from 4,000 to 5,000 board feet of dimension per day.

Analysis of the additional costs and incomes incurred when a bolter saw is added to a conventional sawmill operation revealed that it cost 26 percent less to log and mill bolts than it did logs, partially because stumpage and felling costs are written off against the logs. The net revenue was 17 percent higher for dimension stock than for lumber per thousand board feet lumber tally. This study indicates that a bolter mill, when established in conjunction with a small standard sawmill, can substantially increase total production at a reasonably small investment.

### Chip Behavior in Storage and Handling

In recent years pulpmills have been receiving an ever larger portion of their raw materials in the form of chips from sawmills and other sources.

<sup>2</sup> A sawmill that cuts 8-foot or shorter logs into dimension stock, pallet boards, or other short products.

<sup>3</sup> Log grades based on U.S. Forest Products Laboratory Log Grades for Standard Hardwood Lumber.



F-504523

FIGURE 44. — Tree characteristics are measured in the grading section of the stem and recorded on field punchcards for later analysis.

Because of the meager knowledge of the physics and mechanics of chips and chip aggregates, a research study was undertaken in cooperation with the Michigan Technological University. The study will be concerned with the problems encountered by the chip-producing, transporting, and using industries. The understanding derived from this study will be used as a basis for developing equipment and structures for the handling and storage of chips and chip aggregates.

Industry must learn how to (1) increase the bulk density of chip masses for efficient storage or transportation in containers and (2) increase the fluidity of chip masses for handling.

In the first phase of the study a standard chip will be considered as an individual particle in bulk storage and movement. We will study the behavior



of this chip within a mass that is compacted by various means to determine whether or not changes in density, size, moisture content, and surface contamination will result. In the second phase we will investigate methods for inducing flow in chip masses.

The data developed in this study should aid in the solution of such problems as (1) increasing the bulk density of a mass of chips for storage or

transportation, (2) minimizing bridging when unloading bulk from carriers, (3) reducing loss through blowing from tops of storage piles or from open-topped rail cars and trucks, and (4) transporting chips in an airstream.

Also in progress is a study of methods for segregating bark particles from bodywood chips. This study has not yet supplied enough data to support conclusions.

## UTILIZATION IMPROVEMENT

John R. Neetzel  
St. Paul, Minnesota

A generation ago, wood was a favored farm structure building material because of its general

availability, ease of use, and low cost. Due to the recent mechanization in farming, many of the older farm buildings have become unsatisfactory or obsolete. To secure a greater part of the rural modernization market, producers have developed a number of alternative materials, offering a wide variety for the owner or user to choose from. In the ensuing competition, wood has lost a large volume of potential sales.

In order to further the use of wood and give it a new dimension for farms and in agriculture, the Station has been participating in a number of new studies with the School of Forestry, Agricultural Engineering, and other departments of the Institute of Agriculture, University of Minnesota. These include:

1. Design and construction of experimental barnyard fencing, using penta-treated red pine and jack pine posts and lumber.

2. Design and development of an experimental combination barnyard, lane, and pasture fence on a soils-grassland farm, using penta-treated red and jack pine posts in combination with woven wire and penta-treated rough plank.

3. Development of an insect control structure, using penta-treated red and jack pine posts and rough splashboards.

4. Studies of the environmental influence of turkey shelters constructed with treated pole frames (fig. 45). How will the treated wood react when subjected to unusual moisture conditions, and how will this affect the turkeys' environment?

Since the studies are relatively long term, no results are available at this time. However, future performance data from the studies could do much to increase the use of certain wood products in the highly competitive field of farm structure materials.



F-506321  
FIGURE 45. — Pole frames offer many inexpensive farm building possibilities. In the past, natural irregularities of treated poles made cutting and shimming necessary. This weakened the structure and exposed the cut areas to rot. The author (foreground), working with the University of Minnesota, developed a method for straightening crooked poles by rip-sawing off irregularities before the preservative was applied.



# ECONOMICS OF TIMBER PRODUCTION

Allen L. Lundgren, Project Leader  
Grand Rapids, Minnesota

Whether they are managing existing stands of timber or establishing new stands, forest managers are investing capital resources. To insure that these resources are used efficiently, managers weigh their investment opportunities, estimating for each alternative what the costs and returns will be and when they will occur (fig. 46). Two especially important questions they must answer are: "How should an existing stand of timber be managed to use limited capital resources efficiently?" and "What rate of investment return can be expected from establishing new timber stands?"

As part of a program to help forest owners and managers appraise investment opportunities, production economics research at the Lake States Station is evaluating alternatives in red pine management. The following are a few conclusions from the study.

## Good Sites Give Higher Investment Returns

Investment returns in growing red pine vary greatly with the productivity of land. The better sites produce a greater volume of timber and merchantable trees sooner than the poorer sites. Even allowing for higher establishment costs, the rate of return is higher on the better sites. In appraising investment opportunities, land productivity as measured by site index is one of the most important considerations.

## Low Densities Give Higher Investment Returns

Red pine stands thinned periodically to low densities produce a higher rate of return than those thinned to higher densities, in large part because the trees grow more rapidly in diameter and reach merchantable size sooner. Data from the Station's long-range thinning experiments in Minnesota show that stands thinned to 90 square feet of basal area per acre will earn a higher rate than stands maintained at higher density levels, under current market prices.

## Stand Density, Site, and Market Expectations Affect Financial Maturity

As a red pine stand grows older, the rate of return earned by the trees left or "invested" after

thinning declines steadily. When this rate falls to that which the owner could earn by harvesting the entire stand and investing the money in a new stand of timber or elsewhere, the stand is financially mature and should be cut.

Stand density, site, and future market expectations will affect the financial rotation age of a red pine stand. Generally, low-density stands will have longer financial rotations than high-density stands because they tend to maintain a higher rate of volume and value growth for a longer time. For the same reason, good sites will have longer financial rotations than poor sites as long as there



F-500546

FIGURE 46. — How should this red pine stand be thinned to insure a high rate of investment return from the land and timber? When should the final harvest cut be made? Production economics research at the Lake States Station is exploring the effects of stand density, site, and rotation ages on investment return from growing red pine.



are enough trees to fully occupy the site. If an owner expects stumpage prices to increase in the future, either because of an increase in wood quality or because of a general increase in price levels, then the financial rotation would be lengthened. If prices are expected to fall, the rotation would be shortened.

## FOREST SURVEY

Clarence D. Chase, Project Leader  
St. Paul, Minnesota

Data processing played an important role in the Station's part of the 1962 National Compilation of forest statistics. New resource estimates were computed for Minnesota and Illinois and for one district in Kentucky. The Kentucky field work has progressed well, and the preliminary planning is underway for surveys in Michigan, South Dakota, and Kansas. The Station also has begun to recompute Survey estimates by river basins.

The 1962 Compilation will present the current state of the Nation's timber resources and indicate trends of change. Basic Forest Survey statistics over 4 years old were revised to 1963. Computations of new statistics for Minnesota and Illinois were given top priority so that they, too, might be used. Station survey people prepared over 350 tables for the 13 states that they survey. These will be combined with figures for other areas to arrive at national totals. The Timber Resources Review of 1953 and the 1962 Compilation, together, will be useful for determining trends.

### Data Processing is Valuable Aid

Data processing has become a vital aid to the Station's Forest Survey staff. Certain computations that previously required weeks or months can now be done by machines in *minutes* at tremendous savings. Station survey personnel use the data processing equipment that is maintained by the University of Minnesota (fig. 47).

This year, with the help of an expert programmer, nearly all phases of the complicated survey computations were programmed for machine operation. This included classification of plots from the field sheets; area computations; volume, growth, and some phases of desirable cut computation; regression formulae; some phases of timber cut analysis; and summary. One summary and

The above generalizations indicate the type of information being developed by the Production Economics Project. Data on the economics of growing red pine are now being drawn together into a comprehensive report that will help forest managers and owners evaluate more accurately their investment decisions.

print-out program produces up to 40 tables with 27 species and an average of 12 columns. Large computers will reduce greatly the time lag between completion of fieldwork and availability of final statistics. Also, the machines provide more tables and more details for analyzing the resource.

Computing Minnesota forest resource statistics involved data from 18 counties and 4 groups of counties, including integration of data from 7 co-operators. Since this was the first job done by an elaborate machine, many programming problems had to be solved. The Illinois forest resource statistics were computed much more quickly, since there were only 3 units and no cooperators' data to integrate.



F-505904  
FIGURE 47. — Paul S. DeBald, staff forester, displays items used in computing and reporting forest resource statistics. From his right hand, counterclockwise: field plot tally sheet, punched cards, magnetic tape, machine tabulation, a final table, a research note, and a State report.



## Forests Changing Rapidly

The findings of the Forest Survey project show that the forests of the Lake States are in a period of rapid change and development. Since fire protection became effective, a high proportion of stands have grown through the sapling into the pole stand-size class. Minnesota is a good example of this change. The second survey of Minnesota showed the forest acreage in saplings and seedlings was about equal to that in poletimber. In contrast, the third survey revealed that two-thirds of the acreage in these two size classes is now occupied by poletimber. Stands have been filling rapidly. The second survey showed that over 25 percent of the commercial forest land was nonstocked. The latest survey indicates that this has been reduced to 11 percent of the total. Minnesota's timber volumes have increased rapidly — a wave of young trees has reached merchantable size and growth has accumulated on larger trees. A full report of these changes will be published in 1964 (fig. 48).

During 1963 forest resource reports on Koochiching County, Minn., and the Lake Superior Survey Unit, Minn., were written cooperatively by members of the Office of Iron Range Resources and Rehabilitation and the Experiment Station. The Koochiching County report was published. Also, six research notes have been prepared on various aspects of the Minnesota and Illinois surveys, and a report on timber resources of the Missouri Prairie Region was published by the University of Missouri.

These new reports show significant improvements. Stand and tree quality have been given more emphasis in recent surveys and, of course, repeat surveys provide a measure of change.

Through splendid cooperation of many interested parties, the Upper Peninsula Committee on Area Problems applied for and received a technical assistance grant of funds for new aerial photography there. Due to unfavorable weather during summer only a small part of the photography was accomplished. This will delay the survey of the Upper Peninsula somewhat. The crews will begin the Michigan inventory on about July 1.

During 1963 the Station participated in river basin studies for the Upper Mississippi River and the Grand River (in Michigan). Forest resource statistics were compiled by subbasins.



F-505908

FIGURE 48. — Robert N. Stone, research forester (left), and Clarence D. Chase, project leader (right), discuss a data processing machine tabulation that is part of the information for the report of Minnesota's forest resources. These tabulations, up to 14 columns wide, are printed by the machine at a rate of 1,000 lines per minute.

## Production Changes Noted

The Station's latest timber production studies show that approximately 8¼ million board feet of saw log products, 5¾ million cords of cordwood products, and 17¾ million cubic feet of piece products (total 7½ million cords) were cut in the four Lake States in 1962 (table 5). By volume, cordwood products accounted for three-fourths of the total harvest; saw log products, 22 percent; and piece products, 3 percent.

Station production records show that since 1952 the region's output of lumber logs has declined nearly 30 percent; veneer logs, 40 percent; mine

TABLE 5. — *Timber products output by States, 1962*

State	Saw log products	Cordwood products	Piece products
	MBF <sup>1</sup>	M cords	MCF
Minnesota	173,000	1,700	6,200
Wisconsin	307,000	2,100	5,800
Michigan	340,000	1,900	5,500
North Dakota	1,300	30	200
Total	821,300	5,730	17,700

<sup>1</sup> International ¼-inch log rule.



timbers, 45 percent; and fuelwood and posts, about 35 percent. Pulpwood and pole production were up about 50 percent each.

Because of the declining output of most timber products, the 1962 cut, nationwide, was less than that of 10 years ago. For the Lake States, the total cubic feet cut from growing stock declined 14 percent while the cut from saw log material increased 4 percent (table 6). With more small sawtimber being available for cutting, a larger proportion of timber products are now taken from saw log material.

TABLE 6. — *Timber cut by States, 1962*

State	Volume cut from		Change from 10 years ago	
	Saw log material	Growing stock	Board feet	Cubic feet
	MBF	MCF	Percent	
Minnesota	329,000	136,000	+36	— 8
Wisconsin	467,000	165,000	+16	— 5
Michigan	495,000	166,000	—17	—23
North Dakota	4,000	1,000	—15	—69
Total	1,295,000	468,000	+ 4	—14

## SMALL WOODLAND OWNERSHIP

Con H Schallau, Project Leader  
St. Paul, Minnesota

Most recent timber resource surveys show that the supply of timber in the Lake States is increasing. For example, growth rates in Michigan doubled between 1935 and 1955, and in Minnesota total growing stock volume increased by one-third between 1953 and 1963. But there is a distinction between the physical stock and economic supply of the timber resource. Economic, institutional, and sociological factors could cause a lower economic supply than the physical supply would suggest.

In order to appraise some of these nontimber influences, a study was initiated in 1963 to measure changes in three institutional factors which could temper future timber supplies in the northern half of Lower Michigan. These factors are: (1) absentee ownership, (2) forest land fragmentation and/or consolidation, and (3) property turnover. Changes occurring between 1946 and 1962 are being measured.

The owner's place of residence determines the ease with which he and the buyer can negotiate the sale of timber. Trends in absentee ownership will, therefore, reflect changes in marketing costs. The importance of trends in fragmentation and/or consolidation of forest land is more self-evident. Fragmentation has a direct influence upon both marketing and harvesting costs. The contractor would save considerable expense when logging a compartment of timber if he could deal with 1 owner instead of 10. Furthermore, the contractor would

save harvesting expenses if he could operate throughout a block of 320 acres instead of 8 scattered blocks of 40 acres. Together, changes in absentee ownership and fragmentation might lead to a decrease in the economic supply of timber from a particular timbershed.

Whenever a forest property changes hands, there's always a good chance that the objectives and motives of the new owner will differ from those of the former. This fact has important implications with respect to the "residualness" of forestry assistance programs. In other words, if a forestry assistance program is in effect when a tract of land is sold, will the new owner continue to follow it or will he abandon it? Though the current study will not be concerned with these implications, it will observe the rate at which forestry property changes hands.

The results of this study are not complete, but the following generalizations can be made. Fragmentation and consolidation are both occurring, but the net change during the post-war period has been toward fragmentation. One notable example of this was a 7,800-acre tract which, since 1946, has been cut up into 67 individual parcels (fig. 49). Granted, most of the fragmentation has been more subtle, but the evidence suggests that several large ownerships were dissolved during the 16-year study period.

Absentee ownership is increasing throughout the entire 31-county study area in Lower Michigan.



## Fragmentation of Forest Holdings..... (MICHIGAN, MONTMORENCY COUNTY)

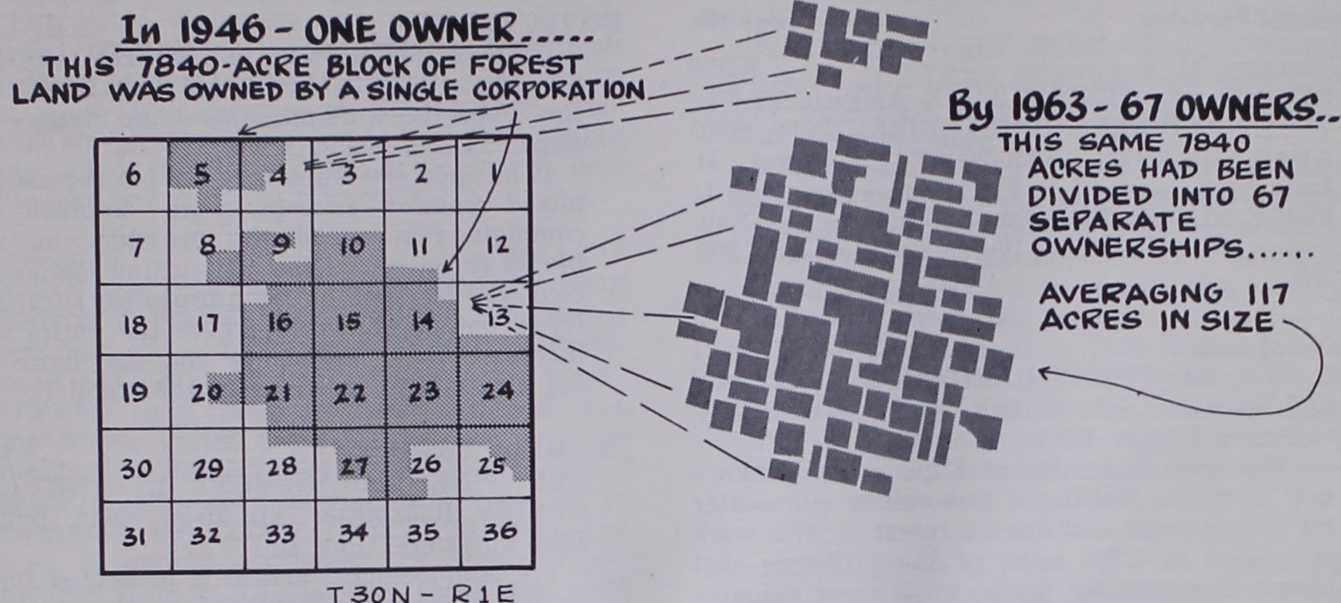


FIGURE 49. — Example of fragmentation of forest land in Montmorency County, Mich.

It is more intense in some sections than others, but in all areas most changes from resident to absentee ownership have occurred since 1954. The larger properties have had stable tenure, but only a minority of all properties have been held by one owner during the entire study period. Approximately one-fifth of the holdings have had at least three different owners during the 16-year period.

Findings of this study suggest need for further research. For instance, how will the permanence of forestry assistance programs be influenced by property turnover? Also, how will absentee ownership and forest land fragmentation and/or consolidation affect the availability of timber products? These and other similar problems should be investigated in the near future.



# Publications in 1963

## LAKE STATES FOREST EXPERIMENT STATION

St. Paul, Minnesota

### General Forestry

### Order No.

Dickerman, M. B. R-320  
 REVIEW OF "RESOURCES IN AMERICA'S FUTURE: PATTERNS OF REQUIREMENTS AND AVAILABILITIES, 1960-2000," by Hans H. Landsberg, Leonard L. Fischman, and Joseph L. Fisher. 1017 pp., illus. Johns Hopkins Press, Baltimore. Jour. Soil and Water Conserv. 18: 208-209.

Falge, James R. R-321  
 U.S.F.S. NORTHERN HARDWOOD RESEARCH CONTINUES AT MARQUETTE, MICHIGAN. Northern Logger 12(4): 8, 9, 29.

(The Lake States Forest Experiment Station's new Northern Hardwood Laboratory is a center for management and disease research. This work is needed to solve some of the problems that plague land managers who grow these valuable hardwoods for the Nation's use. The laboratory was built to satisfy both private and public needs.)

U.S. Forest Service, Lake States Forest Experiment Station R-322\*

1962, 40th ANNUAL REPORT. 62 pp., illus.

(This 40th Annual Report reviews some of the highlights of the Station's activities since it was established. The body of the report discusses some of the recently completed projects and some of the projects installed within the last 2 years.)

### Regeneration, Stand Improvement, and Harvest Cuttings

Arend, John L. RN-LS-12\*  
 CORDWOOD HEIGHTS OF MIXED OAK GROWING ON GRAYLING AND RUBICON SOILS. U.S. Forest Serv. Res. Note LS-12, 2 pp. Lake States Forest Expt. Sta., St. Paul, Minn.

(There was little difference in the cordwood height-d.b.h. relations between the various oak species on both Grayling and Rubicon soils. The number of 8-foot bolts in relation to d.b.h. was fitted best with the quadratic equation:  $Y(\text{No. 8-ft. bolts}) = -3.372 + 1.090 (\text{d.b.h.}) - 0.033 (\text{d.b.h.})^2$ .  $R = +.89$ .  $N = 1,057$  sample trees.)

Benzie, John W. RP-LS-4\*  
 CUTTING METHODS IN MIXED CONIFER SWAMPS, UPPER MICHIGAN. U.S. Forest Serv. Res. Paper LS-4, 24 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(The most favorable results for regenerating mixed conifer swamps were obtained with complete removal of the overstory on small blocks or narrow strips. All cutting methods encouraged competition from broadleaf shrubs and trees, but partial cutting over the entire stand increased their abundance and size more than did clearcutting portions in the stand.)

Buckman, Robert E. R-322  
 RED PINE MANAGEMENT IN THE LAKE STATES. Railsplitter, pp. 25-26, (ann. publ. of Illini Foresters, Univ. Ill.).

(A semi-technical article is presented for the School of Forestry yearbook at the University of Illinois.)

Godman, R. M., and Smith, N. F. RN-LS-17\*  
 INFLUENCE OF REGULAR SPACING ON GROWTH OF A RED PINE PLANTATION. U.S. Forest Serv. Res. Note LS-17, 3 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Uniform spacing in an unmanaged plantation resulted in growth characteristics markedly different from those of natural stands that were comparable at 24 years of age in number of trees, basal area stocking, and average stand diameter. Survival, basal area growth, and merchantable volume yield in the plantation greatly exceeded those of natural stands by age 51, but quality of the trees was probably poorer because of their smaller size and persistence of branch stubs.)

Lohrey, Richard E. RN-LS-24\*  
 HEALING TIME FOR PRUNING WOUNDS IN A RED PINE PLANTATION. U.S. Forest Serv. Res. Note LS-24, 2 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Tree radial growth rate, wound width, and branch stub length all influenced pruning-wound healing time, but date of pruning had no effect. Pruning wounds of average width were usually healed when a layer of wood about as thick as the width of the wound had been formed.)

\* Copies available for distribution.



Lundgren, Allen L., and Wambach, Robert F.

RN-LS-20\*

DIAMETERS AND NUMBERS OF TREES IN RED PINE STANDS ARE GREATLY AFFECTED BY DENSITY, AGE, AND SITE. U.S. Forest Serv. Res. Note LS-20, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Predicted diameters and numbers of trees in red pine stands were compared for stands managed at low, medium, and high densities on two sites. These comparisons illustrated the wide range in diameters and numbers of trees in red pine stands resulting from variations in density, age, and site.)

Roe, Eugene I.

RP-LS-1\*

SEED STORED IN CONES OF SOME JACK PINE STANDS, NORTHERN MINNESOTA. U.S. Forest Serv. Res. Paper LS-1, 14 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Viable seed stored in closed cones of jack pine stands varied from 226,000 per acre for 40-year-old thinned timber to 759,000 for thinned timber of this age. Intermediate were 70- to 80-year-old overmature stands (381,000) and 9- to 13-year-old plantations (477,000). These amounts (1.7 to 5.8 lbs. per acre) are more than enough under favorable conditions to regenerate these stands if destroyed by fire. Trees produce viable seed up to an age of 200 years and possibly longer, but the number of good seeds per cone decreases with stand age.)

Roe, Eugene I.

RP-LS-3\*

DIRECT SEEDING OF CONIFERS IN THE LAKE STATES: A REVIEW OF PAST TRIALS. U.S. Forest Serv. Res. Paper LS-3, 16 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Since 1937, some 130 trials of direct seeding of conifers have been made or reported in the Lake States and adjacent Canada, mostly on upland sites. Forty percent of the seedlings showed good results, but half of them failed. Of the six species tested, jack pine was best. Results were favorable most often when the seed was sown broadcast or in spots on disked land or in fresh burns. Seed losses to birds and rodents and effects of competing vegetation were the most important causes of failure.)

Roe, E. I., and Buchman, Roland G.

R-318\*

EFFECT OF HERBICIDE DOSAGE AND VOLUME ON HAZEL BRUSH AT DIFFERENT FOLIAR STAGES. Forest Sci. 9: 477-484, illus.

(Foliage spraying with water emulsions of two common herbicides applied in three dosages, three volumes, and at five stages of leaf development gave the following results: (1) 2,4-D gave better control of hazel at essentially all stages, (2) 2 pounds of 2,4-D per acre was better than either 1 pound or ½ pound at all stages except midleaf and gave practically complete

control at the shoot-growth-complete stage, (3) the volume of mixture in which the 2,4-D was applied (1, 2, and 4 gallons per acre) did not affect results, and (4) best control was obtained at the shoot-growth-complete stage; the poorest at midleaf; control was intermediate otherwise.)

Rudolf, Paul O.

RN-LS-8\*

1962 FOREST TREE SEED CROP AVERAGES FAIR IN THE LAKE STATES. U. S. Forest Serv. Res. Note LS-8, 2 pp. Lake States Forest Expt. Sta., St. Paul, Minn.

(Seed crops of the principal forest tree species are listed in percentage of a full crop for northern Minnesota, northeastern Wisconsin, central Upper Michigan, Lower Michigan, and north-central North Dakota. In general, the seed crop was below that of 1960 but otherwise better than for any other year since 1955. Crops for most species were fair to good. Compared to 1961, seed production was better in every locality but North Dakota. On the average, production was best in northern Minnesota and diminished steadily to the east.)

Stoeckeler, Joseph H.

RN-LS-27\*

EARLY SURVIVAL OF PLANTED TREES IN SOUTHWESTERN WISCONSIN, BY SPECIES, AGE CLASSES, AND SITE FACTORS. U.S. Forest Serv. Res. Note LS-27, 4 pp. Lake States Forest Expt. Sta., St. Paul, Minn.

(Survivals are given for first and second years for all species combined, and for the commonly planted 2-0, 3-0, and 2-1 red pine on 10 field reforestation plots of various aspects, soils, and topographic positions. Species and age class recommendations are made for six classes of sites.)

Stoeckeler, Joseph H.

RN-LS-28\*

GROUND PREPARATION COSTS AND FIRST-YEAR SURVIVAL OF PLANTED RED PINE IN SOUTHWESTERN WISCONSIN. U.S. Forest Serv. Res. Note LS-28, 4 pp. Lake States Forest Expt. Sta., St. Paul, Minn.

(A comparison is made in field survival and costs for 3-0 and 2-1 red pine planted in five different types of ground preparation; that is, bench terraces, single furrows, double furrows, Lowther machine, and scalps.)

Tubbs, Carl H.

RN-LS-32\*

ARTIFICIALLY CONSTRUCTED MOUNDS SHOW PROMISE IN YELLOW BIRCH REGENERATION. U.S. Forest Serv. Res. Note LS-32, 2 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Seedlings from yellow birch seeded on mounds (a mixture of humus, mineral soil, and leaf litter) scraped from the top 3 to 6 inches of a hardwood forest soil grew much better in each of the first 2 years than seedlings on undisturbed



humus. Growth of seedlings in the leached A-2 mineral soil between mounds was intermediate.)

Tubbs, Carl H. RN-LS-33\*  
ROOT DEVELOPMENT OF YELLOW BIRCH IN HUMUS AND A SANDY LOAM. U.S. Forest Serv. Res. Note LS-33, 2 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Two-year-old yellow birch wildlings were planted in the center of pots; one-half of each pot had been filled (vertically) with sandy loam, the other half with hardwood humus. Root development was much better in the humus even when the mineral soil was given fertilization with 7-6-19.)

### Tree Improvement and Physiology

Church, T. W., Jr. RN-LS-22\*  
SURVIVAL AND GROWTH OF 12-YEAR HYBRID ASPEN COMPARED TO NATIVE WISCONSIN STOCK. U.S. Forest Serv. Res. Note LS-22, 2 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(A test planting of hybrid and native aspens was established in northern Wisconsin in 1951. The hybrid *Populus tremuloides* Michx. of Massachusetts origin X *populus tremula* L. from Munich, Germany, was compared with native *Populus tremuloides*. Twelve years after planting, the hybrid was superior to native Wisconsin aspen in height, diameter, and percentage of survival. The native quaking aspen, however, had better stem form and considerably less canker.)

Clausen, Knud E. RN-LS-31\*  
NURSERY SELECTION AFFECTS SURVIVAL AND GROWTH OF BIRCH. U.S. Forest Serv. Res. Note LS-31, 2 pp. Lake States Forest Expt. Sta., St. Paul, Minn.

(Survival of *Betula pubescens* and *B. pendula* plants after 9 years in the field was directly related to the initial size of the nursery stock. Height and diameter of the trees still reflected the original classification into large, medium, and small seedlings.)

Larson, Philip R. R-304\*  
THE INDIRECT EFFECT OF DROUGHT ON TRACHEID DIAMETER IN RED PINE. Forest Sci. 9: 52-62, illus.

(Moderate drought conditions cause a decrease in tracheid diameter in the wood of the stem. It was suggested that the influence of drought was directly on the growth of the terminal meristems and only indirectly on tracheid diameter through the intermediate action of auxin.)

Larson, Philip R. R-324\*  
STEM FORM DEVELOPMENT OF FOREST TREES. Forest Sci. Monog. 5, 42 pp.

(The biological concept of stem form, or stem taper, is discussed on the basis of a comprehensive review of the literature.)

Rudolf, Paul O., et al. R-305\*  
THE SEED WE USE: PART I. WHAT WE NEED TO KNOW ABOUT IT. (Report of the SAF Seed Certification Subcommittee.) Jour. Forestry 61: 181-184, illus.

(Briefly summarizes the underlying scientific evidence for genetic diversity in wild stands, the need for identifying the source of seed used in artificial regeneration, some of the mechanics for seed source identification, and the probable costs of such activity. It concludes that the identification of seed source and the certification of genetic quality of forest tree seeds are obtainable at reasonable costs, and that the seed buyer should look upon them as an investment in insurance.)

Rudolf, Paul O., et al. R-325\*  
THE SEED WE USE: PART II. HOW TO ASSURE RELIABLE INFORMATION ABOUT IT. (Report of the SAF Seed Certification Subcommittee.) Jour. Forestry 61: 265-269, illus.

(Points out that for generally satisfactory identification or certification of seed, there must be some reliable agency charged with responsibility for such action. Such an agency may be either voluntary or it may be set up by law. In the United States only 12 State laws are interpreted to cover tree seeds. Laws of 9 of these States permit certification, and 5 have developed certification standards for tree seed. The Federal Seed Act backstops State seed laws covering agricultural and vegetable seed, but not tree seed, which enters interstate commerce. Federal legislation also requires fumigation and inspection of all imported seed, including tree seed.)

Watt, Richard F., and R-303\*  
McGregor, Wm. H. Davis  
GROWTH OF FOUR NORTHERN CONIFERS UNDER LONG AND NATURAL PHOTOPERIODS IN FLORIDA AND WISCONSIN. Forest Sci. 9: 115-128, illus.

(Seedlings of white and red pine and white and black spruce were grown under natural and 20-hour photoperiod for 2 years. Long photoperiod permitted growth throughout the 226-day Florida growing season; seedlings at the end of 2 years equaled or exceeded standards for northern-grown transplants. Outplantings in Minnesota had good survival rates. The relatively short



natural Florida photoperiod caused dwarfing of the spruce seedlings. Extended photoperiod in Wisconsin increased the size of 2-year spruce. Morphological changes were noted under long photoperiod at both locations; response to photoperiod varied with age of plants.)

## Silvics

Heinselman, M. L., and Roe, E. I. R-312\*  
A RECORD OF SOME PLEISTOCENE TREES AND SHRUBS FROM ITASCA COUNTY, MINNESOTA. Forest Sci. 9: 336-337.

(Wood specimens found beneath 100 feet of glacial drift in northern Minnesota proved more than 38,000 years old by carbon-14 dating. Present were *Picea*, *Larix laricina*, *Abies balsamea*, *Pinus banksiana*, *Populus alnus*, *Vaccinium*, and cones similar to *Picea mariana*, showing that forests at that time were similar to those of today.)

McCulley, Robert D. R-326  
REVIEW OF "EXOTIC FOREST TREES IN THE BRITISH COMMONWEALTH," BY R. J. STREETS (ed. by Sir Harry Champion), 760 pp., illus. Oxford University Press, New York, 1962. Jour. Forestry 61: 306.

Rudolf, Paul O., and Schoenike, R. L. RN-LS-15\*  
BOTANICAL AND COMMERCIAL RANGE OF JACK PINE IN THE LAKE STATES. U.S. Forest Serv. Res. Note LS-15, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(The botanical and commercial ranges of jack pine in the Lake States are described in the text and illustrated by maps. A supplemental map shows the source of location of specimens in established herbaria. Commercial occurrence is indicated for each county that has at least 1,000 cords of jack pine on commercial forest land.)

## Ecology

Heinselman, Miron L. R-327\*  
FOREST SITES, BOG PROCESSES, AND PEATLAND TYPES IN THE GLACIAL LAKE AGASSIZ REGION, MINNESOTA. Ecol. Monog. 33: 327-374, illus.

(Vast peatlands on the bed of glacial Lake Agassiz in Minnesota possess a remarkable variety of forest sites and peatland types. These include rich swamp forests, bogs supporting productive black spruce-feather moss forests, poor muskegs, and string bogs. Several types belong to a circumboreal family of "patterned bogs," never before recognized this far south on the continent. These peatlands occupy undulating

clay plains, possess slopes of 2 to 15 feet per mile, and blanket entire watersheds. Peat stratigraphy offers evidence of bog expansion and site deterioration. Many vegetation types are topographically oriented, suggesting controls over floristics and sites by the degree of access to mineral-bearing groundwaters.)

## Shelterbelts

Phipps, Howard M. RN-LS-21\*  
GROWTH RESPONSE OF SOME SHELTERBELT SPECIES FOLLOWING SOD REMOVAL — PRELIMINARY RESULTS. U.S. Forest Serv. Res. Note LS-21, 3 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Trees and shrubs growing in two long-established shelterbelts in north-central North Dakota benefited from all degrees of cultivation during a 2-year period following treatment. The response, as measured by increased height, diameter, and crown-spread growth, was directly proportional to the degree of sod removal but varied by species.)

Stoeckeler, J. H. R-328  
SHELTERBELTS AND THEIR EFFECTS ON CROP YIELDS IN THE GREAT PLAINS. Jour. Soil and Water Conserv. 18: 139-144, illus.

(The effects of shelterbelts are discussed in terms of soil and water conservation. The estimated net increases of yield of small grains and corn with 4 lineal miles of east-west, 40-foot-high shelterbelts per square mile are 0.67 and 0.87 bushel per acre respectively.)

## Soils and Water

Bay, Roger R. RN-LS-30\*  
SOIL MOISTURE AND RADIAL INCREMENT IN TWO DENSITY LEVELS OF RED PINE. U.S. Forest Serv. Res. Note LS-30, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(During the 2 years of this study soil moisture did not become low enough to limit radial growth in red pine. The most important relationship indicated was the large increase in diameter growth in the thinned stand, compared to the smaller growth in the denser stand.)

Bay, Roger R., and Boelter, Don H. RN-LS-29\*  
SOIL MOISTURE TRENDS IN THINNED RED PINE STANDS IN NORTHERN MINNESOTA. U.S. Forest Serv. Res. Note LS-29, 3 pp. Lake States Forest Expt. Sta., St. Paul, Minn.

(Soil moisture loss, or use, followed the same depletion trends in three density levels. Autumn



soil moisture deficits were consistently less under lower density stands; however, late fall and overwinter precipitation was required to recharge the soil moisture at all density levels.)

Clegg, Albert G. RN-LS-9\*  
ORGANIC MATTER IMPORTANT IN FIELD ANALYSIS OF SOIL TEXTURE. U.S. Forest Serv. Res. Note LS-9, 2 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(The relationship of organic matter content to differences in silt-plus-clay determinations by the hydrometer and the pipette methods for some North Dakota chernozems is shown graphically. Differences are progressively larger as the percentage of organic matter in the soil sample increases, reaching a maximum of 67.6 percent silt-plus-clay where organic matter content was 7.66 percent.)

Curtis, Willie R. RN-LS-1\*  
FLOW CHARACTERISTICS OF TWO TYPES OF SPRINGS IN SOUTHWESTERN WISCONSIN. U.S. Forest Serv. Res. Note LS-1, 2 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Springs on the Coulee Experimental Forest are found at two levels — approximately 900 and 1,000 feet above sea level. Flow from the 1,000-foot springs is practically constant the year round, while flow from the lower level springs varies by seasons, month, and day in relation to climatic variables. A hydrograph of daily discharge for 1961 for each level of spring is presented.)

Curtis, Willie R. RN-LS-3\*  
DEVICE FOR AUTOMATICALLY STARTING A RECORDING RAIN GAGE WHEN RAINFALL BEGINS. U.S. Forest Serv. Res. Note LS-3, 3 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(The device described allows a recording rain gage to operate only after rainfall begins. Only a few drops of water are necessary to trigger the mechanism. Construction detail is shown in three photos, and the needed materials are listed.)

Sartz, Richard S. RP-LS-6  
WATER YIELD AND SOIL LOSS FROM SOIL-BLOCK LYSIMETERS PLANTED TO SMALL TREES AND OTHER CROPS. U.S. Forest Serv. Res. Paper LS-6, 23 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Surface runoff, percolation, and soil loss from lysimeters with different cover were measured for 6 years. Mulched tree seedlings and grass yielded little runoff and soil during growing season, while unmulched seedlings and grain yielded large amounts. Differences by cover type

were less distinct in the dormant season. Most of the percolation occurred during the dormant season. Annual variation was high in both seasons.)

Stoeckeler, Joseph H. R-302\*  
A REVIEW OF FOREST SWAMP DRAINAGE METHODS IN NORTHERN EUROPE. Jour. Forestry 61: 99-104, illus.

(Growth improvement of trees in swamps in northern Europe by drainage is usually in the range of 15 to 60 cubic feet per acre per year. It is accomplished largely through a system of open ditches made at a cost of 2 to 4 cents per lineal foot, or 5 to 10 dollars per acre. Cheapest costs are achieved with large winch-drawn plows. Back hoes and dynamite are also used to some extent.)

Stoeckeler, Joseph H. R-307\*  
SPRINGTIME FROST FREQUENCY NEAR LA CROSSE, WIS., AS AFFECTED BY TOPOGRAPHIC POSITION, AND ITS RELATION TO POTENTIAL REFORESTATION PROBLEMS. Jour. Forestry 61: 379-381, illus.

(Frosts of 30° F. or less were eight times more abundant in a 2-year period in a cove at elevation of 920 feet above sea level than in a nearby ridgetop at 1,250 feet elevation.)

Stoeckeler, J. H., and Walker, L. C. R-311\*  
LEGUMES AND LIME: EUROPEAN FORESTRY AIDS. Better Crops with Plant Food 47(2): 33-38, illus.

(The seeding of legumes such as perennial lupines, sometimes supplemented by lime, had the effect of supplying a long-persisting form of nitrogen in European forest plantations, amounting to 107 to 134 pounds per acre. Liming promoted growth of the legume on acid soils and, in turn, of the tree plantations; it accelerated decomposition of raw humus under cool acidic conditions. In U.S. forest nurseries, addition of potash greatly improved frost resistance of a number of lupine species.)

Walker, L. C., and Stoeckeler, J. H. R-311\*  
FERTILIZERS FOR EUROPEAN FORESTS. Better Crops with Plant Foods 47(3): 15-22, illus.

(Striking improvements (two- to four-fold increases) in growth of trees have been achieved by fertilization in Germany, Sweden, The Netherlands, Norway, Finland, and France. Fertilizer amounts were in the range of 500 to 1,500 pounds per acre and often involved nitrogen, phosphorus, and potash.)



Weitzman, Sidney, and Bay, Roger R. RP-LS-2\*  
FOREST SOIL FREEZING AND THE INFLUENCE OF MANAGEMENT PRACTICES, NORTHERN MINNESOTA. U.S. Forest Serv. Res. Paper LS-2, 8 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Depth and duration of concrete frost were observed on three different soil textural classes with a number of plant cover conditions. Sandy soils had less concrete freezing than fine-textured soils, the pattern of freezing in organic soils was similar to mineral soils, and thinning conifers and hardwoods slightly reduced incidence and depth of frost.)

#### Forest Insects

Ewan, H. G. R-329  
MAN AGAINST INSECT, LAKE STATES AREA. IN A FOREST WORLD REPORT ON INSECT CONDITIONS ACROSS THE UNITED STATES. Forest World 2(1): 13-16.

(With the diversity of tree species and growing sites in the Lake States, a great array of insect pests reach damaging levels. A few of the "bad actors" in 1962 attacking natural conifers, plantations, and hardwoods are discussed. Some pests are being routinely controlled, some resist conventional methods, still others need an evaluation of their damage potential.)

Miller, William E. R-319\*  
THE SHORTLEAF PITCH-BLISTER MOTH, PETROVA HOUSERI Miller. Ohio Jour. Sci. 63: 297-301, illus.

(This insect kills twigs of shortleaf pine, trees of all sizes being affected. Only recently known to science, it occurs in three States (Ohio, West Virginia, and Georgia) and probably will be found in more.)

Miller, William E., and Schallau, Con H. R-314\*  
PROBLEMS IN IDENTIFYING OLD EUROPEAN PINE SHOOT MOTH DAMAGE. Jour. Forestry 61: 677-678, illus.

(Old tree damage indistinguishable from that caused by the European pine shoot moth was found at 4.5 percent of nodes in plantations in Minnesota, where the insect is not known to occur.)

Talerico, Robert L. RN-LS-7\*  
NATURAL MORTALITY OF THE ZIMMERMAN PINE MOTH IN THREE MICHIGAN PLANTATIONS. U.S. Forest Serv. Res. Note LS-7, 2 pp., illus. Lake States Forest Expt. Sta, St Paul, Minn.

(Between June and August, populations declined by about 90 percent due to obscure causes.)

Talerico, Robert L., Heikkinen, Herman J., R-306\* and Miller, William E.

GROWTH OF RED PINE TREES AFTER CHEMICAL SUPPRESSION OF THE EUROPEAN PINE SHOOT MOTH. Canad. Ent. 95: 522-524.

(Height growth and number of side branches the first growing season following suppression were not improved by spring treatments. However, they were improved in proportion to the degree of pest reduction by summer treatments.)

Wilson, Louis F. R-309\*  
HOST PREFERENCE FOR OVIPOSITION BY THE SPRUCE BUDWORM IN THE LAKE STATES. Jour. Econ. Ent. 56: 285-288, illus.

(In both laboratory and field tests white spruce was preferred over balsam fir for oviposition by the female moth. The average preference ratio was about 2.2:1 in laboratory tests and 2.3:1 in field tests. Balsam fir was preferred over black spruce.)

Wilson, Louis F. FPL-77\*  
THE GREEN-STRIPED MAPLEWORM. U.S. Forest Serv., Forest Pest Leaflet 77, 4 pp., illus.

(Discusses briefly the current knowledge on the life history, hosts, damage, range, and habits of the insect and suggests means for its suppression.)

Wilson, Louis F., and Bean, James L. R-315\*  
SITE OF SPRUCE BUDWORM EGG MASSES ON THE PREFERRED HOSTS IN THE LAKE STATES. Jour. of Econ. Ent. 56: 285-288, illus.

(Number of egg masses is correlated directly with branch size and branch height in the crown. This holds true for lightly to moderately defoliated balsam fir and white spruce, and for severely defoliated balsam fir. Egg masses are laid on the side of the needle associated with a higher density of adjacent needles. Needles that are 4.0 mm to 7.0 mm apart are preferred for oviposition.)

#### Forest Diseases

Anderson, Gerald W. FPL-79\*  
SWEETFERN RUST ON HARD PINES. U.S. Forest Serv., Forest Pest Leaflet 79, 7 pp., illus.

(Describes the fungus and its life history. Also, contains illustrations of alternate hosts and of damage caused on pine seedlings and large trees.)



Anderson, Gerald W., and R-317\*  
Anderson, Ralph L.

THE RATE OF SPREAD OF OAK WILT IN THE LAKE STATES. Jour. Forestry 61: 823-825, illus.

(In southeastern Minnesota and central Wisconsin 42 percent of the surveyed oak wilt infection centers increased in size annually. The average rate of increase was 3.2 feet per year. New center establishment was 1.7 for each 100 acres of type sampled. Enlargement and establishment rates could not be correlated with stand and site factors.)

Anderson, Neil A. FPL-80\*  
EASTERN GALL RUST. U.S. Forest Serv. Forest Pest Leaflet 80, 4 pp., illus.

(Describes the fungus and its life history. Also contains illustrations of infection on jack pine and the alternate host.)

Anderson, Neil A., and RN-LS-26\*  
Anderson, Gerald W.

WHITE PINE ROOT ROT AT THE CHITTENDEN NURSERY. U.S. Forest Serv. Res. Note LS-26, 3 pp., illus.

(*Cylindrocladium scoparium* Morg., a fungus that causes root rot at other Lake States forest nurseries, was isolated from the soil at the Chittenden Nursery, using the alfalfa technique. It was not recovered directly from the seedlings. It is suggested that this fungus may have caused the damage to white pine which has occurred at this nursery in previous years.)

Benzie, John W., Hesterberg, Gene, and R-313\*  
Ohman, John H.

PATHOLOGICAL EFFECTS OF LOGGING DAMAGE FOUR YEARS AFTER SELECTIVE CUTTING IN OLD-GROWTH NORTHERN HARDWOODS. Jour. Forestry 61: 786, 788, 790, 792.

(Reports the results of dissections made on yellow birch and sugar maple trees wounded in logging. Little lumber degrade had occurred after 4 years.)

Hard, John S. RN-LS-5\*  
FROST DAMAGE TO RED PINE CONELETS. U.S. Forest Serv. Res. Note LS-5, 2 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(A profile of conelet mortality shows dead conelets in the lower part of tree crowns and live conelets in the upper portions. Circumstantial evidence points to frost as the cause of mortality.)

Kessler, K. J., Jr. RN-LS-13\*  
DIEBECK OF SUGAR MAPLE, UPPER MICHIGAN, 1962. U.S. Forest Serv. Res. Note LS-13, 2 pp. Lake States Forest Expt. Sta., St. Paul, Minn.

(Observations made annually since 1958 indicate that dieback has increased each year (from 10.0 percent in 1958 to 27.9 percent in 1962). Dieback was most severe on trees in the larger size classes and in the most heavily cut stands.)

Ohman, John H., and Kessler, K. J., Jr. RN-LS-10\*  
CURRENT STATUS OF THE SAPSTREAK DISEASE OF SUGAR MAPLE IN THE LAKE STATES. U.S. Forest Serv. Res. Note LS-10, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Twelve more positive cases and seven probable cases of sapstreak were found in Marquette Co., Mich., during 1962. One positive case was found in Baraga Co., Mich. Logging injuries to residual trees in selectively logged stands are incriminated as entry courts for the sapstreak fungus.)

Phipps, Howard M. R-310\*  
THE ROLE OF 2,4-D IN THE APPEARANCE OF A LEAF BLIGHT OF SOME PLAINS TREE SPECIES. Forest Sci. 9: 283-288, illus.

(Describes three methods used to relate a leaf blight of windbreak trees to herbicide (specifically a phenoxyacetic acid compound) damage. The sensitivity of boxelder foliage to applied 2,4-D was tested, and the very young leaf buds found to be malformed by as little as .01 microgram. All tests indicate that 2,4-D is the cause of the blight.)

Van Arsdel, E. P. RN-LS-18\*  
A SIMPLE WEATHER INSTRUMENT SHELTER FOR PLANT DISEASE INVESTIGATIONS. U.S. Forest Serv. Res. Note LS-18, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Presents the design and procedure for building a lightweight, low-cost shelter for hygromographs and other meteorological instruments. Discusses the proper location of weather instruments for microclimate studies.)

## Fire

Beale, John A., and Dieterich, John H. R-330  
CROWN FIRE PROBLEMS IN THE LAKE STATES. Wis. Conserv. Bul. 28(1): 12-13, illus.



(Crown fires are becoming a more serious threat to conifer stands because of increased forest use and the ever-increasing areas of new plantations. A better means of predicting both fuel moisture and critical fire weather is needed as a warning system for crown fires. Better planning, better utilization of present equipment, and the development of new specialized equipment will contribute to a better system of crown fire control.)

Brown, James K. RN-LS-19\*  
CROWN WEIGHTS IN RED PINE PLANTATIONS. U.S. Forest Serv. Res. Note LS-19, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Using crown weight measurements of individual trees, a method was developed to predict the amount of tree crown fuel in plantation stands that vary by age, site, and stand density as well as the amount of slash fuel that would result from various levels of pulpwood cutting. The proportion of needles to the total crown weight was also determined.)

Dieterich, John H. R-331  
FIRE AND SAND. Wis. Conserv. Bul. 28(4): 18-19, illus.

(The combination of pine type and sandy soils creates a fire situation that is potentially dangerous throughout the spring, summer, and fall. Larger fires and more frequent fires occur in the dry sandy areas of Wisconsin that support extensive stands of young pine.)

Dieterich, J. H. RN-LS-14\*  
LITTER FUELS IN RED PINE PLANTATIONS. U.S. Forest Serv. Res. Note LS-14, 3 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(The surface litter fuels under plantation stands are an important contributing factor to fire spread and intensity. This study established a standard method of sampling litter fuels and predicting the amount of surface material available in red pine plantation stands that vary in stand density.)

## Wildlife

Brander, Robert, and Stearns, Forest W. RN-LS-16\*  
PORCUPINE WINTER FEEDING ACTIVITY IN MERCHANTABLE STANDS OF NORTHERN HARDWOOD-HEMLOCK. U.S. Forest Serv. Res. Note LS-16, 2 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Trees felled in a commercial improvement cutting showed winter feeding (including barking and twig clipping) in 5 percent of the tops when the porcupine population was moderately large, about 40 to 50 animals per square mile. Since deformed trees had been cut to improve the stand, the percentage of the remaining trees attacked was probably somewhat smaller. Many of the tops showed feeding over a period of several years, indicating that the animals tend to return to the same trees year after year. Thus, with a stable animal population, only a small number of trees will be gnawed for the first time in any given winter.)

## Sampling and Research Methodology

Buckman, Robert E. R-332  
REVIEW OF "FOREST MENSURATION AND STATISTICS" by BERTRAM HUSCH. 440 pp., illus., 1963. Ronald Press Co., New York. Jour. Soil and Water Conserv. 18: 169-170.

Curtis, Willie R. R-300\*  
TOOL FOR EDITING ANALOG-TO-DIGITAL TAPES. Jour. Soil and Water Conserv. 17: 254, illus.

(Describes details of construction and use of a tool that aids in the editing and computing of punched tape obtained with analog-to-digital recorders.)

## Forest Economics

Blyth, James E., and Gronseth, Glenn O. RN-LS-6\*  
LABOR POTENTIAL FOR EXPANDING FOREST INDUSTRIES IN NORTHEASTERN MINNESOTA, OCTOBER 1962. U.S. Forest Serv. Res. Note LS-6, 2 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Describes the labor force seeking permanent employment through the Minnesota State Employment Offices in October 1962 in Pine, Carlton, St. Louis, Lake, and Cook Counties. More than two-fifths of the 4,764 applicants were under 35 years old; 18 percent were skilled laborers; and more than 40 percent had high school diplomas or college training.)

King, David A. R-301\*  
FOREST LAND CLASSIFICATION FOR PROPERTY TAX ASSESSMENT PURPOSES IN WISCONSIN. Land Econ. 39: 96-99.



(A sample of forest properties sold between 1954 and 1958 in three Wisconsin counties was analyzed. A comparison of sale values between forest condition classes showed no differences. Multiple regression analysis of four independent variables within condition classes showed no significant relationship with sale value.)

Lundgren, Allen L. R-308\*  
AN ECONOMIC ANALYSIS OF THREE PINE RELEASE EXPERIMENTS IN NORTHERN MINNESOTA. Forest Sci. 9: 242-256, illus.

(A method for evaluating release alternatives was developed and applied to three long-term experiments on releasing sapling stands of red and white pine from an aspen-birch overstory in northern Minnesota. The analysis indicated that release of sapling red and white pine stands can be highly profitable under some conditions.)

Morgan, James T. R-338  
PROSPECTS FOR INCREASED USE OF WISCONSIN TIMBER. Governor's Conf. on Resource and Industrial Development Proc., pp. 96-100. (Conf. at Green Lake, Wis., May 22-23, 1963.)

(Discusses problems of oversupply in small-size hardwoods, increasing land values, and inadequate knowledge of wood performance and the economies of timber growing. Lists progress in developing better utilization.)

Quinney, D. N., and Schallau, C. H. R-316\*  
LAKE STATES FOREST LANDS IN A CHANGING ECONOMY. Land Econ. 39: 421-428, illus.

(Discusses changes in land use in the Lake States and the contemporary and projected interrelationships between forest lands, agricultural, and urban areas. Speculates that if present trends continue, the next several decades may find greater specialization in land use, with northern areas being more completely devoted to forestry and recreation and southern areas to intensive agricultural and urban development.)

#### Resource and Production Statistics

Gansner, David A., and Chase, Clarence D. R-333  
TIMBER RESOURCES OF THE MISSOURI PRAIRIE REGION. Univ. Mo. Agr. Expt. Sta. B 797, 40 pp., illus.

(Forest areas, timber volumes, growth, actual cut, and desirable cut are presented for the northern and the southwestern prairies of Missouri. Areas and volumes are given insofar as feasible for each county in these areas.)

Gansner, David A., and RN-CS-2  
Knutson, Robert G.

ILLINOIS PRODUCES 122 MILLION BOARD FEET OF LUMBER IN 1961. U.S. Forest Serv. Res. Note CS-3, 4 pp., illus. Available at Central States Forest Expt. Sta., Columbus, Ohio.

(Shows Illinois lumber production by species and number of active sawmills by county.)

Horn, Arthur G. RN-LS-11\*  
CHANGES IN NORTHERN MINNESOTA TIMBER HARVEST. U.S. Forest Serv. Res. Note LS-11, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Presents timber cut and timber products output figures, number of primary wood-using plants, and value of forest products and man-days of work expended in harvesting of products for 17 northern counties and the State.)

Horn, A. G. RN-LS-23\*  
LAKE STATES PULPWOOD PRODUCTION UP WHILE CANADIAN IMPORTS DROP TO ALL-TIME LOW, 1962. U.S. Forest Serv. Res. Note LS-23, 2 pp. Lake States Forest Expt. Sta., St. Paul, Minn.

(Shows 1962 pulpwood production by species and destination of wood produced in each of the three Lake States. Shows imports from other States and Canada.)

Horn, A. G. RP-LS-5\*  
PULPWOOD PRODUCTION IN LAKE STATES COUNTIES, 1962. U.S. Forest Serv. Res. Paper LS-5, 16 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(This paper shows pulpwood production for 1962 by county and species for each of the Lake States and compares production by species and Forest Survey District for several previous years.)

Office of Iron Range Resources and R-334  
Rehabilitation and Lake States  
Forest Experiment Station.

FOREST RESOURCE OF KOOCHICHING COUNTY, MINN. Office Iron Range Resources and Rehab., 64 pages, illus.

(Presents forest areas, growing stock, timber production, forest industries, and the timber balance — growth, cut, and desirable cut.)

Stone Robert N., and RN-LS-25\*  
Vasilevsky, Alexander M.

FOREST AREA TRENDS IN MINNESOTA COUNTIES. U.S. Forest Serv. Res. Note LS-25, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Presents current forest areas and changes occurring since the previous survey by county.)



## Marketing and Utilization

Carpenter, Eugene M. RN-LS-4\*  
LAKE STATES WOOD-PRODUCT IMPORTS  
AND EXPORTS VIA THE ST. LAWRENCE SEA-  
WAY. U.S. Forest Serv. Res. Note LS-4, 2 pp.  
Lake States Forest Expt. Sta., St. Paul, Minn.

(Presents data on the trends in import and export of wood products, including pulp and paper items, through Lake States ports since the St. Lawrence Seaway was opened to deep-draft ocean vessels in 1959. A small but steady increase has occurred in both imports and exports in all categories, with imports by far the major movement due to large amounts of woodpulp moving into the area.)

Neetzel, John R., and R-335  
Christopherson, C. H.  
SHOULD WOOD POSTS BE POINTED FOR  
POWER DRIVING? Minn. Farm and Home Sci.  
21(1): 12-13, illus.

(The study shows the desirability of using pointed wood posts and of driving in wet as compared to dry soil. When driving in dry soil, there is an advantage in having the large end pointed, but in wet soil the posts should be pointed on the small end. While no great advantage is indicated for posts sharpened on the large rather than the small end, other studies have shown that placing the large end in the ground increases the post's resistance to overturn, so pointing the large end should be favored.)

## Forest Recreation

Lucas, Robert C. RN-LS-2\*  
VISITOR REACTION TO TIMBER HARVESTING  
IN THE BOUNDARY WATERS CANOE AREA.  
U.S. Forest Serv. Res. Note LS-2, 3 pp., illus. Lake  
States Forest Expt. Sta., St. Paul, Minn.

(The Boundary Waters Canoe Area of the Superior National Forest is the only National Forest location managed for both wilderness-type recreation and timber. Sample groups, interviewed at all access points after their visits, noticed logging seldom (18 percent of all groups) and only 30 percent of those noticing logging said they were bothered by it.)

Lucas, Robert C. R-336\*  
BIAS IN ESTIMATING RECREATIONISTS'  
LENGTH OF STAY FROM SAMPLE INTER-  
VIEWS. Jour. Forestry 61: 912-914.

(Estimates of length of stay from on-site samples (of campers, for example) are biased upward. This previously unrecognized bias is large, but a simple weighting procedure removes its effect.)

Morgan, James T. R-337  
SOME ELEMENTS IN THE DEMAND FOR OUT-  
DOOR RECREATION. *In* Economics of Outdoor  
Recreation in the Upper Midwest, Univ. of Minn.,  
Duluth, pp. 269-272.

(Some introductory remarks at the Upper Midwest Recreation Resources Institute, Duluth.)



UNITED STATES DEPARTMENT OF AGRICULTURE  
FOREST SERVICE  
LAKE STATES FOREST EXPERIMENT STATION  
ST. PAUL CAMPUS, UNIVERSITY OF MINNESOTA  
ST. PAUL 1, MINNESOTA

IN REPLY REFER TO:

1380

April 14, 1965

Dear Sir:

Enclosed is an annotated list of publications released during 1964 by the Lake States Forest Experiment Station. We are sending it and this letter to you as our Annual Report for 1964. Many of you have already received some of the publications. If you want copies of others on the list that are marked with an asterisk (\*), please send us your requests.

Our accomplishments during 1964 and the variety of our research efforts are indicated by the titles of our publications. I will take this opportunity, however, to summarize briefly some 1964 highlights in our research program and changes in our staff and facilities which, I believe, will be of greatest interest to you.

During 1964 Forest Survey fieldwork was completed in Kentucky, and new surveys were started in Michigan, Kansas, and South Dakota. Field inventories covered about 7 million acres of forest land; and 13 forest resource reports were issued by the Station and its cooperators.

Our forest products marketing research, headquartered with the University of Minnesota at Duluth, is primarily directed toward expanding outlets for forest products, thus helping to create additional employment in the heavily forested northern Lake States region. During 1964 our marketing specialists completed appraisals of the labor and water resources and transportation facilities available to forest products industries in five northeastern Minnesota counties. Marketing studies also were begun on the hardwood veneer and particleboard industries of the northern Lake States.

Among the results of our work in tree physiology and tree improvement are several papers that discuss factors affecting the formation of wood. Such knowledge provides a scientific basis for modifying wood characteristics through alternative systems of forest management and silvicultural methods. A guide was developed for selecting superior trees for shelterbelts in the Prairie Plains which will help foresters locate superior seed sources and vegetative material for the production of better trees for planting. Two staff members presented papers at international meetings--one on the use of induced mutations in plant breeding, the other on progress in setting nationwide standards for tree seed certification.





Our fire research program was reoriented and expanded to include all Forest Service research on fire control systems and methods for the Lake States, Central States, and Northeastern States. Primary goals will be development of regional fire danger rating systems, advanced fire fighting methods, and ways to use prescribed fire in forest land management in these regions.

During 1964 we adapted the National Fire Danger Rating System to local conditions in the North Central Region. Also, a method of measuring the contribution of jack and red pine crowns to the potential fuel reservoir of plantations in the Lake States was worked out. This identifies the increase in fire hazard as more trees are planted and established plantations grow older.

In forest insect and disease work, the Station started research on biological control measures. For example, two studies were begun on the use of micro-organisms for insect control--one concerns a virus disease that attacks the pine tussock moth, the other deals with the possibilities of insect-attacking fungi. Continuing progress was made in determining the effects of microclimate on white pine blister rust, with resulting substantial savings in control programs.

Population dynamics studies on insect pests are providing a new framework for predicting population fluctuations and developing control techniques. This has already helped to curtail infestations by the European pine shoot moth and pine root collar weevil.

In watershed management research, our work in Michigan has shown that forest cover types influence ground water yields. Differences in yields from forests of hardwoods and of dense conifers were found to be associated with high snow interception and early spring transpiration drain in pine forests. In the Driftless Area surrounding LaCrosse, Wis., we obtained promising results in preventing erosion through water spreading on hill-sides and water diversion by channels. In northern Minnesota bogs we learned a good deal about the water storage capacity of several peats--knowledge that is needed before we can manage our millions of acres of swamps and bogs to the best advantage.

The most heavily used wilderness-type recreation area in the Nation is the Boundary Waters Canoe Area in the Superior National Forest of Minnesota. The continuing controversy over management of this unique forested recreational area emphasizes the need for facts on which to base policy and management decisions. In 1964 the Station contributed two helpful reports on recreational use and capacity of the BWCA.

Research facilities were greatly improved in 1964. On September 11, the new Headquarters Laboratories and Main Office of the Station, located on the St. Paul Campus of the University of Minnesota, was dedicated by Edward P. Cliff, Chief of the U.S. Forest Service. Plans were completed



for a Forest Engineering Laboratory at Houghton, Mich. The site for a radiation field at the Institute of Forest Genetics at Rhineland, Wis., was prepared, and the source will be installed in 1965. To better accommodate visitors attending the many work conferences held at the Kawishiwi Experimental Forest, a dining hall and auditorium were added to our facilities there.

Several changes were made during the year in key staff positions. Director M. B. Dickerman accepted an assignment in Washington, D.C., as Forest Service representative on the staff of Dr. Nyle C. Brady, Director of Science and Education, U.S. Department of Agriculture. I was pleased to receive the appointment as Director of the Lake States Station and to return to my native State and the campus where I received my forestry training. During the past 9 years I served on the Forest Service staff in Washington, D.C.,--most recently as Assistant to the Deputy Chief in Charge of Research.

Other key personnel changes included the appointment of K. W. McNasser, as Chief, Division of Station Management, replacing James E. Sowder. McNasser was formerly Chief of the Division of Fire Research at the Southeastern Forest Experiment Station. Dr. William E. Miller moved to the Headquarters Laboratories and Main Office in St. Paul to become the Leader of our Seed and Cone, Aspen, and Shelterbelt Insects Project. He was succeeded as Leader of the Plantation Insects Project at East Lansing by Dr. Louis F. Wilson. Von J. Johnson from Alaska replaced John H. Dieterich as Leader of our Fire Control Systems Project. The Wildlife Habitat Research Project, headed by Dr. Forest Stearns, was transferred from St. Paul to Rhineland, Wis. Robert F. Wambach was made Leader of the Plantation Management Project at Cadillac, Mich. He replaced Richard M. Godman, who was transferred to Rhineland to take charge of the Argonne Experimental Forest. Transfers to other Stations included Thomas W. Church, formerly in charge of the Argonne, and Rulon B. Gardner, who was Leader of the Forest Engineering Project at Houghton, Mich.

In keeping with our policy of increasing the technical competence of our research staff, practically all members participated in training assignments, and 12 scientists received additional formal graduate training during the year. This, along with the realignment of personnel, improvement in our research facilities, and careful planning of our program will lead, we hope, to even greater accomplishments in 1965.

Sincerely yours,

*D. B. King*

D. B. KING,  
Director

Enclosure



PUBLICATIONS IN 1964  
by the  
Lake States Forest Experiment Station  
St. Paul Campus, University of Minnesota  
St. Paul, Minn. 55101

General Forestry

Order No.

Dickerman, M. B.

RESEARCH: A GUIDE TO PROGRESS IN MINNESOTA FORESTRY. North.  
Logger 12(9): 18, 19, 52, 53, 56; illus.

R-371

(Briefly describes some of the major studies underway in  
several fields of forest research.)

Dickerman, M. B.

UNLOCKING SECRETS OF THE FOREST. Conserv. Volunteer (Minn.)  
27(154): 45-47, illus.

R-370

(Describes briefly some research advances in the management  
of Minnesota's forests and water.)

U.S. Forest Service, Lake States Forest Experiment Station.

R-373

ANNUAL REPORT, 1963. Lake States Forest Expt. Sta. 63 pp.,  
illus.

(Reviews Station news during 1963 and briefly describes the  
more important studies in each of the Station's 27 active  
research projects.)

U.S. Forest Service, Lake States Forest Experiment Station.

R-389

RESEARCH PROGRAM AT THE LAKE STATES FOREST EXPERIMENT STATION.  
20 pp., illus.

(A popularized information booklet that (1) reviews the  
history of the Station, (2) describes the more important  
forestry problems in the Lake States and Northern Prairie Plains,  
and (3) outlines the current research programs.)

Wilson, Louis F.

REVIEW OF "ASPENS, PHOENIX TREES OF THE GREAT LAKES REGION" by  
S. A. Graham, R. P. Harrison, Jr., and C. E. Westell, Jr. 272  
pp., illus. Univ. of Mich. Press, Ann Arbor, 1963. Ent. Soc.  
Amer. Bul. 10: 208.

R-393

LIBRARY COPY  
ROCKY MOUNTAIN  
EXPERIMENT STATION

Regeneration, Stand Improvement, and Harvest Cuttings

Arend, John L.

R-364

4 AMINO-3,5,6-TRICHLOROPICOLINIC ACID IS EFFECTIVE HERBICIDE FOR  
TREE INJECTORS. No. Central Weed Control Conf. Ann. Res. Rpt.  
1963: 109-110. (Pub. in 1963.)

(Tordon 22K (2 lb. acid equiv. gal.) controlled northern red  
oak under 12 inches d.b.h. by basal injections at the following  
volumes and spacing of the injections (edge to edge): 1/4 - 1/2 ml.  
for 2-inch spacing, 3/4 ml. at 4-inch spacing, and 1 ml. at 6-inch  
spacing. Tordon 101 mixture required double these volumes.)

\* Available on request to the Lake States Forest Experiment Station, Forest  
Service, U.S.D.A., University of Minnesota, St. Paul Campus, St. Paul, Minn.



Arend, John L.

2,4,5-T CONCENTRATIONS IN PARTIAL FRILL GIRDLES. No. Central R-365  
Weed Control Conf. Ann. Res. Rpt. 1963: 107-109. (Pub. in 1963.)

(Solutions of two forms of 2,4,5-T--(1) a water-soluble triethylamine salt, and (2) an oil-soluble propylene glycol butyl ether ester--were injected in oak at different concentrations. The amine formulation (2 lbs. acid equiv. per gal.), applied at 4 mls. per injection spaced 2 inches apart, was very effective for most hardwoods under 12 inches d.b.h.)

Benzie, John W., and Ringold, Stanley B.

A TEST OF CONCENTRATED SILVICIDES ON SUGAR MAPLE. U.S. RN-LS-37 \*  
Forest Serv. Res. Note LS-37, 2 pp. Lake States Forest Expt. Sta., St. Paul, Minn.

(Amine salts of 2,4-D were more effective than those of 2,4,5-T for killing cull sugar maple trees. Applying the silvicide in freshly cut frills was more successful than applying it with a tree injector. But there was no significant difference between the two concentrations of chemicals used, 2 or 4 lbs. acid equivalent per gallon.)

Buckman, Robert E.

TWENTY-TWO-YEAR RESULTS OF A PRECOMMERCIAL THINNING EXPERIMENT IN JACK PINE. U.S. Forest Serv. Res. Note LS-46, 2 pp. Lake States Forest Expt. Sta., St. Paul, Minn. RN-LS-46 \*

(Stand characteristics are given 22 years after a pre-commercial thinning of then 5-year-old jack pine to spacings of 4x4, 6x6, and 8x8 feet, plus unthinned controls.)

Cooley, John H.

THE EFFECT OF SELECTION CUTTING ON CULL IN NORTHERN HARDWOODS. R-361 \*  
Jour. Forestry 62: 823-824.

(Comparison of cull on plots in old-growth timber indicates that cull is sharply reduced by proper application of the selection system; 40 percent of the volume removed in the first cut was unmerchantable, 20 percent in the second cut, and only 4 percent in the third.)

Dickerman, M. B.

REPRODUCTION METHODS IN RELATION TO PULPWOOD PRODUCTION. R-372  
Pulpwood Ann. 1964: 89-91, illus.

(Presented at the 1964 annual meeting of the American Pulpwood Association. Describes various methods recommended for restocking large areas with trees and the methods now being used.)

Roe, Eugene I.

HEAVY CROP OF RED PINE CONES YIELDS MANY THOUSANDS OF GOOD SEEDS. U.S. Forest Serv. Res. Note LS-36, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn. RN-LS-36 \*

(Viable seed produced by the 1957 cone crop varied from 916,000 per acre in a 90-year-old managed stand to only 89,000 in a 50-year-old managed stand; a 90-year-old natural stand produced 370,000 seeds. Half the seed fell during October, some during winter, and a significant amount during the spring and early summer months. Seed soundness decreased as time elapsed.)



Scholz, Harold F.

RP-LS-7 \*

SEEDING AND PLANTING TESTS OF NORTHERN RED OAK IN WISCONSIN.  
U.S. Forest Serv. Res. Paper LS-7, 7 pp., illus. Lake States  
Forest Expt. Sta., St. Paul, Minn.

(A 10-year test in southwestern Wisconsin indicates that  
it is feasible to regenerate northern red oak either by direct  
seedings of acorns or by planting 1-0 or 2-0 nursery stock.  
Losses of the small trees caused by rodents or competing  
vegetation can be reduced by proper controls.)

Scholz, Harold F., and Bell, Harold C.

RN-LS-35 \*

VARIABLE STOCKING IS A PROBLEM IN EXPERIMENTS INVOLVING  
DIRECT SEEDINGS OF NORTHERN RED OAK. U.S. Forest Serv. Res.  
Note LS-35, 2 pp. Lake States Forest Expt. Sta., St. Paul, Minn.

(In a 10-year regeneration study of northern red oak,  
plantings of 1-0 and 2-0 nursery stock were more satisfactory  
than direct seedings. Individual trees always can be identified  
in plantings, whereas such precise accountability often is  
difficult in direct seedings involving several stems per spot  
and recurring changes in their number.)

Stoeckeler, J. H.

R-359 \*

TWO-YEAR RESULTS OF DIRECT-SEEDED BLACK WALNUT IN A COVE ON THE  
COULEE EXPERIMENTAL FOREST, LA CROSSE, WIS. U.S. Forest Serv.  
Tree Planters Notes 67: 12-13.

(A second-year stocking of 85 percent and a germination of  
49 percent were achieved in a direct field seeding involving  
three seeds per seed spot in conventional 12-inch-wide furrows.)

Tubbs, Carl H.

RN-LS-34 \*

GERMINATION OF YELLOW BIRCH SEED FOLLOWING NATURAL STRATIFICA-  
TION IN UPPER MICHIGAN. U.S. Forest Serv. Res. Note LS-34,  
2 pp. Lake States Forest Expt. Sta., St. Paul, Minn.

(Yellow birch seed was stratified at monthly intervals  
during the fall and winter to simulate natural seedfall and  
stratification. Germination tests under outdoor conditions  
indicate that fall-stratified seed will germinate in early  
spring while that stratified in winter months will not germinate  
until midsummer or later.)

See also R-360 and R-354 under "Fire."

#### Tree Improvement and Physiology

Dawson, David H., and Read, Ralph A.

RP-LS-13 \*

GUIDE FOR SELECTING SUPERIOR TREES FOR SHELTERBELTS IN THE  
PRAIRIE PLAINS. U.S. Forest Serv. Res. Paper LS-13, 22 pp.,  
illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Discusses and illustrates desirable characteristics  
such as growth rate, crown form, and resistance to pathogenic  
and physiogenic diseases of 17 tree species; for use as an aid  
in selecting superior phenotypes for shelterbelt usage.)



Larson, Philip R.

R-350

CONTRIBUTION OF DIFFERENT-AGED NEEDLES TO GROWTH AND WOOD FORMATION OF YOUNG RED PINES. Forest Sci. 10: 224-238, illus.

(Each age class of needles contributes differently to total stem growth, distribution of growth along the stem, and the structure of the wood produced. The contributions of the needles also vary during the growing season.)

Larson, Philip R.

R-374

EVALUATING THE ENVIRONMENT FOR STUDIES OF THE INHERITANCE OF WOOD PROPERTIES. In World Consultation of Forest Genet. and Tree Improvement Proc. Vol. II (7/1): i-v, 1-6. (Summaries in English, French, and Spanish.) (Pub. in 1963.)

(A unified concept of wood quality is presented whereby the effects of environment from many situations may be interpreted.)

Larson, Philip R.

R-375

MICROSCOPIC WOOD CHARACTERISTICS AND THEIR VARIATION WITH TREE GROWTH. Intl. Union Forest Res. Org., Forest Prod., Sect. 41 Proc., Sept. 11-13, 1963, 24 pp. (Pub. in 1963.)

(An attempt is made to relate different tracheid dimensions (diameter, length, wall thickness) to growth processes within the tree crown by tracing pertinent developmental processes.)

Larson, Philip R.

R-376

SOME INDIRECT EFFECTS OF ENVIRONMENT ON WOOD FORMATION. In "The Formation of Wood in Forest Trees," pp. 345-365, illus. New York: Academic Press.

(The role of environment, particularly photoperiod, light intensity, and drought, are discussed with regard to their influence on tracheid diameter and secondary wall thickening.)

Larson, Philip R.

R-346

STEM FORM AND SILVICULTURE. Soc. Amer. Foresters Proc. 1963: 103-107, illus.

(Stem form, or stem taper, can be markedly altered by silvicultural measures such as thinning and pruning. In every case, the change in stem form is preceded by an alteration in crown size or vigor.)

Nienstaedt, Hans.

R-352

A LOOK AT FOREST TREE IMPROVEMENT WORK IN SCANDINAVIA, WEST GERMANY, AND HOLLAND. Jour. Forestry 62: 456-462.

(Describes forest tree genetics and tree breeding work in Sweden, Norway, Denmark, West Germany, and Holland. Research is stressed. The relationship between the research and breeding approach and the forest management practices and evolutionary history of important European species is discussed.)



Rudolf, Paul O.

R-360

\*

FOREST TREE IMPROVEMENT IN THE LAKE STATES, 1953-1963.

In Sixth Lake States Forest Tree Improvement Conf. Proc.

U.S. Forest Serv., Lake States Forest Expt. Sta., St. Paul, Minn. pp. 1-16.

(Reviews the status of forest tree improvement work in the Lake States in 1953 when the Lake States Forest Tree Improvement Committee was formed; summarizes the advances from 1953-1963 by agencies and by subject matter; relates contributions of action agencies; and takes a look ahead.)

Rudolf, Paul O.

R-384

FOREST TREE SEED CERTIFICATION IN THE UNITED STATES AND SOME PROPOSALS FOR UNIFORMITY. In World Consultation on Forest

Genet. and Tree Impr. Proc. Vol. II, FAO FORGEN 63 - 8/3:

i-v, 1-9. (Summaries in English, French, and Spanish.) (Pub. in 1963.)

(Traces the history and development of forest tree seed certification in the United States and stresses recent activities of the States, independent agencies, International Crop Improvement Association, and Society of American Foresters. Points out the international need for uniform tree seed certification standards and proposes that the ICIA-SAF scheme be used as a guide. Suggests four classes of seed be designated in an international scheme: certified, selected, source-identified, and general run.)

Rudolf, P. O., et al.

R-383

REPORT OF THE SAF TREE SEED COMMITTEE: 1964 ACTIVITIES.

Jour. Forestry 62: 910-914.

(Recounts the activities of the SAF Tree Seed Committee concerning tree seed certification, legislation, and related matters; and of other agencies concerned with tree seed. Points out action needed on tree seed matters and recommends action on tree seed legislation, other means of seed control, adequacy of present certification standards, and continued close contact with the Sections and with other organizations concerned with tree seed problems.)

Rudolf, P.O., et al.

R-382

\*

REPORT OF THE SAF TREE SEED COMMITTEE TO THE DIVISION OF SILVICULTURE, SOCIETY OF AMERICAN FORESTERS. Jour. Forestry 62: 658-672.

(In its first year of activity the SAF Tree Seed Committee agreed on five policy statements; summarized the situation concerning tree seed certification, legislation, and testing; established liaison with all SAF Sections and with other organizations dealing with tree seed; proposed actions to improve tree seed control; and assembled a list of all committees and organizations concerned with tree seed in the United States and some foreign countries.)



Rudolph, Thomas D.

LAMMAS GROWTH AND PROLEPSIS IN JACK PINE IN THE LAKE STATES.  
Forest Sci. Monog. 6, 70 pp., illus.

(Presents results of a study made to determine the characteristics of lammas growth and prolepsis in jack pine, the variation in occurrence of these phenomena over the range of the species in the Lake States, their effects on height growth, tree form, and annual ring structure, and the possible factors influencing their occurrence in certain areas and on individual trees, especially seed origin.)

R-357 \*

Rudolph, T. D., and Nienstaedt, Hans.

ROOTING, SHOOT DEVELOPMENT, AND FLOWERING OF JACK PINE  
NEEDLE FASCICLES. Silvae Genet. 13: 118-123, illus.

(Presents results of a study designed to develop a technique for rooting jack pine needle fascicles. It was found that fascicles with preformed buds from 2-year-old trees could be rooted with up to 70-percent success when treated with 0.1 percent indolebutyric acid and placed in a heated greenhouse bench. Shoot development was excellent on rooted fascicles with preformed buds, and, occasionally, male strobili developed on the shoots shortly after the fascicles had rooted.)

R-360 \*

U.S. Forest Service, Lake States Forest Experiment Station.  
PROCEEDINGS OF THE SIXTH LAKE STATES FOREST TREE IMPROVEMENT  
CONFERENCE, SEPTEMBER 1963. 90 pp., illus. Lake States  
Forest Expt. Sta., St. Paul, Minn.

(Includes papers on recent studies concerning tree improvement and related research, subcommittee reports, and descriptions of experiments seen on the field trip.)

### Silvics

RN-LS-51 \*

Hard, John S.

VERTICAL DISTRIBUTION OF CONES IN RED PINE. U.S. Forest  
Serv. Res. Note LS-51, 2 pp., illus. Lake States Forest  
Expt. Sta., St. Paul, Minn.

(A survey of cone-bearing red pines showed that although cones were more abundant in midcrown, they were more concentrated in the upper crown in relation to age and amount of foliage. Conversely, flowers were more abundant in the lower crown.)

### Shelterbelts

R-387 \*

Stoeckeler, J. H.

DESIGN OF SHELTERBELTS FOR AGRICULTURAL LANDS IN RELATION TO  
MICROCLIMATE AND IMPROVED SOIL EROSION CONTROL. World Crops  
16(4): 20-23, illus. (Summary in French, Spanish, and  
English, p. 3.)

(Discusses design of field shelterbelts in relation to their effect on wind velocity, evaporation, snow trapping, and reduction of wind erosion.)



## Soils and Water

Bay, Roger R., and Klawitter, Ralph A.

R-344 \*

WHAT'S NEW IN WETLAND HYDROLOGY. Soc. Amer. Foresters. Proc. 1963: 175-177, illus.

(Describes wetland forests, their uses and problems, and current research being carried out in wetland hydrology in the southeastern Coastal Plain and the northern Lake States. Results of these early studies have pointed to some broad watershed management implications.)

Boelter, D. H.

R-368 \*

LABORATORY TECHNIQUES FOR MEASURING WATER STORAGE PROPERTIES OF ORGANIC SOILS. Soil Sci. Soc. Amer. Proc. 28: 823-824.

(Artificially drying or disturbing of peat samples changes their water retention properties significantly from those of undried, undisturbed samples. Procedures are given that permit the use of pressure plate and membrane equipment to measure the water storage characteristics of organic soils.)

Boelter, D. H., and Blake, G. R.

R-349 \*

IMPORTANCE OF VOLUMETRIC EXPRESSION OF WATER CONTENTS OF ORGANIC SOILS. Soil Sci. Soc. Amer. Proc. 28: 176-178, illus.

(Because bulk densities of moss, herbaceous and aggregated peats varied from 0.028 to 0.249 g./cc., a highly distorted impression of the amount of water actually held under field conditions is given if water contents are expressed on an oven-dry weight basis. Since there is considerable shrinkage on drying, bulk densities must be calculated on the basis of the wet bulk volume.)

Boelter, D. H.

R-351 \*

WATER STORAGE CHARACTERISTICS OF SEVERAL PEATS IN SITU. Soil Sci. Soc. Amer. Proc. 28: 433-435, illus.

(Sphagnum moss peat in surface horizons contained more than 95 percent water by volume at saturation or 10 to 20 percent more than decomposed and herbaceous peats in deeper horizons. The moss peat released more than 65 percent of its water between saturation and 0.1 bar suction and retained less water than the decomposed or herbaceous peats at higher suctions.)

Sartz, Richard S.

RN-LS-40 \*

DURATION OF PERCOLATION FROM A LOESS SOIL. U.S. Forest Serv. Res. Note LS-40, 2 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Percolation from 4-foot deep lysimeters filled with loess soil was studied in southwestern Wisconsin. After complete soil moisture recharge, percolation flowed continuously for as long as 20 days without additional rainfall.)



Striffler, W. David

RP-LS-16 \*

SEDIMENT, STREAMFLOW, AND LAND USE RELATIONSHIPS IN NORTHERN LOWER MICHIGAN. U.S. Forest Serv. Res. Paper LS-16, 12 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Reports results of a study relating sediment and stream discharge rates to the major land-use types and streambank erosion within the Michigan Tobacco River watershed.)

Weitzman, Sidney.

R-391

REVIEW OF "ARIDITY AND MAN" by Carl Hodge and Peter C. Duisberg. Amer. Assoc. Advancement Sci., Washington, D.C. 604 pp., illus. 1963. Jour. Forestry 62: 348.

Weitzman, Sidney.

R-392

THE WATER OF THE LAKE STATES--A VITAL AND CRITICAL RESOURCE. Northern Logger 12(11): 8, 9, 32, 33, 37, illus.

(Describes the water resource of the Lake States area by three physiographic units: (1) northern swamps, (2) gully and erosion area, and (3) the ground water area. Outlines the importance of water to the region's economy, the competition for available supplies, and the research challenges and opportunities.)

#### Forest Insects

Bean, James L., and Wilson, Louis F.

R-362 \*

COMPARING VARIOUS METHODS OF PREDICTING DEVELOPMENT OF THE SPRUCE BUDWORM, CHORISTONEURA FUMIFERANA (CLEM.), IN NORTHERN MINNESOTA. Jour. Econ. Ent. 57: 925-928, illus.

(The four methods examined were: degree-hour temperature summation, day-degree temperature summation, actual shoot growth of balsam fir, and 15-percent shoot growth of balsam fir. Degree-hour method was the most accurate, but day-degree method was easiest to calculate and more practical.)

Hard, John S.

RP-LS-12 \*

THE IDENTIFICATION OF PRIMARY RED PINE CONE INSECTS.

U.S. Forest Serv. Res. Paper LS-12, 10 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Keys and illustrations of cone damage and insect characteristics are presented to aid in identifying the six insect species most destructive to red pine cones in the Lake States.)

MacAloney, H. J., and Ewan, H. G.

RP-LS-11 \*

IDENTIFICATION OF HARDWOOD INSECTS BY TYPE OF TREE INJURY, NORTH-CENTRAL REGION. U.S. Forest Serv. Res. Paper LS-11, 70 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Contains identification aids, including many illustrations, of insects affecting hardwoods. Hosts, injury, and characteristics of each insect are briefly discussed.)



MacAloney, H. J., and Wilson, Louis F.

FPL-14 \*

RED-HEADED PINE SAWFLY. U.S. Forest Serv. Forest Pest Leaflet 14, 5 pp., illus. (Rev. 1964)

(A revised up-to-date version on the life history, hosts, range, damage, and habits of the insect, with suggestions for its control.)

Miller, W. E., and Wilson, Louis F.

R-358 \*

COMPOSITION AND DIAGNOSIS OF PINE TIP MOTH INFESTATIONS IN THE SOUTHEAST. Jour. Econ. Ent. 57: 722-726, illus.

(Nearly half of 22 samples of pine tip moth adults reared from injured tips in seven southeastern States consisted of more than one of the three species of tip moth found there. A guide for separating adults and larvae of these close relatives is presented, and binomial confidence limits are proposed for practical use in diagnosing infestations from samples of moths.)

Ryan, Stephen O., and Batzer, Harold O.

RN-LS-39 \*

SPRUCE BUDWORM DEFOLIATION IN NORTHEASTERN MINNESOTA DECREASES IN 1963. U.S. Forest Serv. Res. Note LS-39, 2 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Noticeable spruce budworm defoliation for 1963 was observed on 246,800 acres of spruce-fir type compared with 607,100 acres for 1961. Reduction took place mostly along the eastern and southern edges and through mortality of spruce-fir type. Maps of current defoliation and of mortality zones are given.)

Schmiede, Donald C.

R-353 \*

A NOTE ON THE TAXONOMY OF AN UNDESCRIBED INSECT PARASITIC NEMATODE IN THE GENUS NEOAPLECTANA. Parasitology 54: 233-236, illus.

(Considers the nomenclature problem of "DD-136," an unidentified nematode of biological control interest, concluding that it is probably conspecific with Neoaplectana carpocapsae Weiser.)

U.S. Forest Service, Lake States Forest Experiment Station.  
THE CAUSES OF MAPLE BLIGHT IN THE LAKE STATES. U.S. Forest Serv. Res. Paper LS-10, 15 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

RP-LS-10 \*

(This paper is a final report summarizing all studies of the maple blight problem in Wisconsin by the several cooperating agencies. The primary cause of maple blight was found to be insect defoliation during a critical period in July and early August.)



R-355 \*

Wilson, Louis F.

OVIPOSITION SITE OF THE SPRUCE BUDWORM, CHORISTONEURA FUMIFERANA,  
MODIFIED BY LIGHT. Ent. Soc. Amer. Annals 57: 643-645.

(Lighted ends of balsam fir and white spruce branches  
always had four times more egg masses than the darkened ends.  
This was true whether the apical or basal end was illuminated.  
It was thought oviposition pressure forced normally light-  
sluggish females to oviposit.)

R-356 \*

Wilson, Louis F.

OBSERVATIONS ON GEO-ORIENTATION OF SPRUCE BUDWORM,  
CHORISTONEURA FUMIFERANA, ADULTS. Ent. Soc. Amer. Annals  
57(5): 645-648, illus.

(Observations were made on resting, copulatory, and  
ovipositional orientation to gravity. At rest, vertical  
geonegative orientation is the rule for both sexes. During  
copulation females orient geonegatively while males orient  
in the opposite direction. The common stance is geonegative  
during oviposition, but occasionally geopositive stances are  
taken.)

FPL-82 \*

Wilson, Louis F.

WALKINGSTICK. U.S. Forest Serv. Forest Pest Leaflet 82,  
4 pp., illus.

(Discusses briefly the current knowledge on the life history,  
hosts, range, damage, and habits of the insect, and suggests means  
for its control.)

RN-LS-53 \*

Wilson, Louis F., and Bean, James L.

A FIELD KEY TO THE ADULT HYMENOPTEROUS PARASITES OF THE  
SPRUCE BUDWORM IN MINNESOTA. U.S. Forest Serv. Res. Note  
LS-53, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(This simple key separates the genera of the adult hymenopterous  
parasites of Choristoneura fumiferana (Clem.) inhabiting northern  
Minnesota. Included is a list of all the species recorded from  
thousands of rearings from 1956 to 1961. Seven insect families are  
represented that include 36 species.)

### Forest Diseases

R-363

Anderson, Ralph L.

DISEASES OF ABIES. In Diseases of Widely Planted Forest Trees.  
Internatl. Union of Forestry Res. Organ. Sect. 24, Forest  
Protection. Symposium, July 20-30, 1964, pp. 1-16.

(A compilation of worldwide information on pathogens  
currently or potentially capable of causing serious losses  
to tree species belonging to the genus Abies.)



Anderson, Ralph L.

HYPOXYLON CANKER IMPACT ON ASPEN. In Symposium on Cankers of Forest Trees. Phytopath. 54: 253-257, illus.

(Presents current status of knowledge on the impact of hypoxylon canker on aspen and the influence of environmental factors on prevalence of infection, based on long-term study of 469 field plots. Also discusses the serious difficulties involved in analyzing this kind of data.)

RP-LS-14 \*

Ohman, John H., and Kessler, K. J., Jr.

BLACK BARK AS AN INDICATOR OF BIRD PECK DEFECT IN SUGAR MAPLE. U.S. Forest Serv. Res. Paper LS-14, 8 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Blackened areas on sugar maple trunks are caused by a fungus complex growing saprophytically on the bark surface following repeated wounding and subsequent release of large quantities of sap. Sapsucker attacks on the lower bark are the principal incitant. Their attacks on sugar maple are confined almost exclusively to black-barked trees, and all such trees examined had been heavily and repeatedly attacked. Black bark can serve as an indicator of possible bird peck defect.)

FPL-88 \*

Ohman, John H., and Kessler, K. J., Jr.

WHITE TRUNK ROT OF HARDWOODS. U.S. Forest Serv. Forest Pest Leaflet 88, 7 pp., illus.

(Discusses briefly current knowledge concerning hosts, symptoms, damage, life history, and control of the rot caused by the fungus Fomes igniarius.)

RN-LS-49 \*

Phipps, Howard M.

LEAF BLIGHT OF BOXELDER ATTRIBUTED TO 2,4-D SPRAY DRIFT. U.S. Forest Serv. Res. Note LS-49, 2 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(2,4-D was shown to be responsible for a leaf blight of boxelder and other Plains' tree species by the results of foliar analysis, indicator plant responses, and related tests.)

R-386

Skilling, D. D.

ECOLOGICAL FACTORS ASSOCIATED WITH MAPLE BLIGHT. Part V In Studies of Maple Blight. Univ. Wis. Res. Bul. 250: 115-128, illus.

(The complete syndrome of maple blight was reproduced artificially. Artificial defoliation and soil moisture reduction had the greatest effect on the development of maple blight symptoms.)



Van Arsdel, E. P.

R-394

(Five abstracts as listed below) In Abstracts, Third International Biometeorological Congress, Sept. 1-7, 1963, Pau (S. France). (Pub. in 1963.)

WEATHER AND WHITE PINE BLISTER RUST, p. 43.

METHODS OF STUDY OF AERIAL SPORE TRANSPORT, p. 44

DATING FIELD INFECTIONS OF PIRICULANA ORYZAE BY THE COMBINED USE OF METEOROLOGICAL DATA FROM THE FIELD

AND LABORATORY DATA OBTAINED IN CONTROLLED ENVIRONMENT, p. 45

ORIGIN OF EPIDEMICS IN WHITE PINE BLISTER RUST, p. 45

RELEASE OF SPORIDIA IN BLISTER RUST OF WHITE PINE, p. 46.

Van Arsdel, Eugene P.

RN-LS-42 \*

GROWING WHITE PINES TO AVOID BLISTER RUST--NEW INFORMATION FOR 1964. U.S. Forest Serv. Res. Note LS-42, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Updates control information previously presented in Station Paper 92 by providing improved pictures for canker identification, a revised map for determining the intensity of control required in various parts of the Lake States, and some guides for identifying ribes bushes.)

Van Arsdel, E. P.

R-390

NIGHT BREEZE - BLISTER RUST SPREAD RELATIONSHIPS ON LAKE STATES WHITE PINES. (Abs.) Amer. Meteor. Soc. Bul. 45: 404.

(Evidence from canker distribution in trees reinforced by air-flow patterns traced by smoke and balloons shows that rust spread usually follows certain patterns fixed by night breezes resulting from local temperature and pressure differences.)

Weber, Ray

RN-LS-38 \*

EARLY PRUNING REDUCES BLISTER RUST MORTALITY IN WHITE PINE PLANTATIONS. U.S. Forest Serv. Res. Note LS-38, 2 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Pruning off all lower branches on young white pines every 2 years from planting time until the lowest branches were 4 feet from the ground on 9-foot-tall trees reduced the percentage of fatally infected trees from 59 percent in the unpruned to 19 percent in the pruned trees.)

See also RP-LS-10 under "Insects."



Brown, James K.

HOURLY VARIATION IN FIRE DANGER IN THE LAKE STATES.

U.S. Forest Serv. Res. Note LS-45, 2 pp. Lake States Forest Expt. Sta., St. Paul, Minn.

(Hourly spread index values and wind velocities were examined for April, July, and October at four First Order Weather Bureau Climatological Stations to determine what time of day the highest fire danger occurs and the advisability of using 1:00 p.m. as the time for daily fire danger measurements.)

R-354 \*

Huckman, Robert E.

EFFECTS OF PRESCRIBED BURNING ON HAZEL IN MINNESOTA.

Ecol. 45: 626-629, illus.

(Single or repeated spring prescribed burning easily kills aerial stems of hazel, but prolific resprouting follows each fire. Single and repeated summer fires also kill aerial stems, but resprouting is progressively less vigorous after each fire. Single summer fires after a prolonged drouth can eliminate hazel.)

R-360 \*

Dieterich, J. H.

USE OF FIRE IN PLANTING SITE PREPARATION. In Sixth Lake States Forest Tree Improvement Conf. Proc. (1963): 22-29. Lake States Forest Expt. Sta., St. Paul, Minn.

(Presents advantages and limitations of fire use for seedbed and outplanting site preparation. Burning trials have been successful on some red pine, jack pine, and black spruce sites.)

RN-LS-47 \*

Dieterich, J. H., and Brown, James K.

COMPARING SEVERITY OF FIRE SEASONS. U.S. Forest Serv. Res. Note LS-47, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Buildup index of the national system of fire danger rating, an indicator of progressive drying conditions, is described and used along with precipitation and temperature in comparing the severity of the 1936 and 1961 fire seasons in northern Minnesota.)

Sampling and Research Methodology

Strickler, Gerald S., and Stearns, Forest W.

R-388

THE DETERMINATION OF PLANT DENSITY. In Range Research Methods, A Symposium, Denver, Colo., May 1962. U.S. Dept. Agr. Misc. Pub. 940: 30-40, illus. (Pub. in 1963.)

(Plant density, i.e. number of individuals per unit area, is a common measure of populations in range and wildlife habitat studies. It is particularly valuable in examining distribution of species and composition of stands. Distance quadrat and angle methods for density determination and the use of density measures are discussed.)



Lundgren, Allen L.

THE ROLE OF PRODUCTION ECONOMICS IN FOREST MANAGEMENT.

Soc. Amer. Foresters Proc. 1963: 159-162.

(Production economists evaluate a wide range of problems to assist the forest manager in his complex job of managing capital efficiently. To be more effective, economists will have to develop better production models and work out methods of analysis that can be quickly applied in the field.)

R-379

Morgan, James T.

WHAT'S HAPPENING TO MINNESOTA TIMBER? Northern Logger 12(9): 28, 38, 47, illus.

(The "physical" supply of timber is building up in Minnesota, creating apparent surpluses in low-value species. The "available" supply is probably considerably smaller, depending on the interaction of plus factors such as tree planting and minus factors such as competing uses for forest land.)

R-339

Quinney, Dean M.

SMALL PRIVATE FOREST LANDOWNERSHIP IN THE UNITED STATES-- INDIVIDUAL AND SOCIAL PERCEPTION. Natural Resources Jour. (Pub. by Univ. of New Mex.) 3: 379-393.

(Discusses the historical background and the current importance of small private forest landownership to the nation's overall timber resources. Using a specific study of landowners in northern Michigan as a frame of reference, it points out the contrasts between social and individual perception of resource use and value, and the reasons for these differences.)

RP-LS-9 \*

Schallau, Con H.

FOREST OWNERS AND TIMBER MANAGEMENT IN MICHIGAN. U.S. Forest Serv. Res. Paper LS-9, 39 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Summarizes three studies of small private ownership in Michigan. But it also discusses the role of large private and public ownership in the State's forest economy. Public forests are contributing more than their share of Michigan's timber cut, and prospects are good that they will continue to do so for some time.)

R-341

Schallau, Con H.

A RATIONALE FOR FUTURE SMALL WOODLAND RESEARCH IN THE LAKE STATES. U.S. Forest Serv., 11 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Suggests that one cannot fully understand the "small forest ownership problem" unless the overall economic and sociological environment is also studied. Ownership research should strive to achieve more abundant production of consumer goods from small forest tracts, products that are more economical than so-called wood substitutes.)



Schallau, Con H.

R-385

REVIEW OF "RURAL LAND TENURE IN THE UNITED STATES" Edited by Alvin L. Bertrand and Floyd L. Corty, La. State Univ. Press, Baton Rouge, 313 pp., 1962. Jour. Forestry 62: 41.

Vasilevsky, Alexander, and Stone, Robert N.

RN-LS-44 \*

OWNERSHIP OF COMMERCIAL FOREST LAND IN MINNESOTA, 1962.

U.S. Forest Serv. Res. Note LS-44, 3 pp. Lake States Forest Expt. Sta., St. Paul, Minn.

(Presents data on ownership of commercial forest area in Minnesota by Forest Survey units. In addition, ownership of commercial forest land is shown for 18 heavily forested northern Minnesota counties. Little change was noted in the proportion of commercial forest in the public and private ownership between the Forest Surveys of 1953 and 1962.)

#### Estimation of Timber Volume

Lease, Robert E., and Benzie, John W.

RN-LS-50 \*

A CUBIC-FOOT VOLUME TABLE FOR UNPEELED PINE POLES. U.S. Forest Serv. Res. Note LS-50, 2 pp. Lake States Forest Expt. Sta., St. Paul, Minn.

(Presents a cubic-foot volume table for unpeeled red and jack pine poles ranging from 4 to 9 inches in top diameter and 10 to 45 feet long.)

#### Resource and Production Statistics

Chase, Clarence D.

RN-LS-55 \*

FOREST TYPE AREAS BY COUNTIES, MINNESOTA, 1962. U.S. Forest Serv. Res. Note LS-55, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Presents 1962 forest type areas by counties and shows trends in forest type areas since 1953 by survey units.)

DeBald, Paul S., and Stone, Robert N.

RN-LS-43 \*

MINNESOTA'S TIMBER VOLUME. U.S. Forest Serv. Res. Note LS-43, 4 pp. Lake States Forest Expt. Sta., St. Paul, Minn.

(Shows a 37-percent increase in growing stock volumes since 1953 and presents both growing stock and sawtimber volumes by counties and species groups as of 1962.)

Essex, Burton L., and Gansner, David A.

RN-CS-21

FOREST AREA IN ILLINOIS, BY COUNTIES, 1962. U.S. Forest Serv. Res. Note CS-21, 4 pp., illus. Central States Forest Expt. Sta., Columbus, Ohio.

(Presents areas of forest land in Illinois by counties in 1962 and changes since 1948.)



Horn, Arthur G.

LAKE STATES PULPWOOD CUT CONTINUES TO CLIME: WISCONSIN TAKES LEAD IN PULPWOOD PRODUCTION [1963]. U.S. Forest Serv. Res. Note LS-48, 2 pp. Lake States Forest Expt. Sta., St. Paul, Minn.

(Shows 1963 pulpwood production by species and destination of wood produced in each of the three Lake States. Shows imports from other States and Canada.)

Horn, Arthur G.

PULPWOOD PRODUCTION IN LAKE STATES COUNTIES, 1963. U.S. Forest Serv. Resource Bul. LS-1, 17 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Shows pulpwood production for 1963 by county and species for each of the Lake States and compares production by species and Forest Survey District for several previous years.)

Knutson, Robert G.

VENEER LOG PRODUCTION IN THE LAKE STATES CONTINUES GENERAL DECLINE, 1963. U.S. Forest Serv. Res. Note LS-54, 4 pp., illus. Lake States Forest Expt. Station, St. Paul, Minn.

(Shows 1963 production and destination of veneer logs in the Lake States, origin of veneer logs received at Lake States mills, and trends in the Lake States veneer industry since 1946.)

Office of Iron Range Resources and Rehabilitation and Lake States Forest Experiment Station.

#### TIMBER RESOURCES OF MINNESOTA:

CARLTON COUNTY, 1962. 24 pp., illus.

COOK COUNTY, 1962. 24 pp., illus.

LAKE COUNTY, 1962. 24 pp., illus.

PINE COUNTY, 1962. 23 pp., illus.

ST. LOUIS COUNTY, 1962. 26 pp., illus.

LAKE SUPERIOR UNIT, 1962. 42 pp., illus.

(Each county report presents data on forest area, ownership, timber volumes, forest industry, and the timber balance (growth, cut, and desirable cut). The Lake Superior Unit report summarizes these data and indicates trends since 1953. Copies of these reports are available at the Office of Iron Range Resources and Rehabilitation, 60 State Office Building, St. Paul, Minn. 55101.)



## Marketing, Utilization, and Engineering

Blyth, James E.

R-366 \*

THE LABOR RESOURCE FOR EXPANDING WOOD-USING INDUSTRIES IN NORTHEASTERN MINNESOTA. U.S. Forest Serv. 27 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Discusses the quality, mobility, and size of the unemployed labor resource seeking permanent work and the adaptability of this resource to forest industry employment. Presents labor cost data in local forest industry and compares forest industry labor costs on a regional basis.)

Blyth, James E.

R-367 \*

WATER RESOURCES FOR EXPANDING WOOD-USING INDUSTRIES IN NORTHEASTERN MINNESOTA. U.S. Forest Serv. 34 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Presents data on potential sites for new or expanding pulp and composition-board plants in five counties. The primary consideration was the availability of sufficient water of good quality to support a minimum economic-size plant without causing pollution.)

Blyth, James E., and Therrien, Edward N.

RN-LS-52 \*

PRIMARY WOOD USE BY MANUFACTURING FIRMS IN DULUTH-SUPERIOR, 1962. U.S. Forest Serv. Res. Note LS-52, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Discusses volume of lumber used by species, grade, region of origin, surface and moisture condition, and end use, and presents data on volumes of plywood, hardboard, and particleboard used. Speculates that future demand for Lake States lumber for industrial purposes is reasonably good and that opportunities probably exist for local fabricators, using native lumber, to supply a larger share of assembled wooden containers to industrial customers.)

Carpenter, Eugene M.

R-369

TRANSPORTATION FACILITIES FOR DEVELOPING WOOD-USING INDUSTRIES IN NORTHEASTERN MINNESOTA. U.S. Forest Serv. 34 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Describes the transportation facilities and services available in northeastern Minnesota. Data are also available for shipping rate comparisons to Midwest market cities for several forest products. Covers rail, truck, and seaway shipping resources in a five-county study area.)



Gardner, Rulon B.

ENGINEERED SYSTEMS APPROACH TO HARVESTING, HANDLING, AND TRANSPORTING PROBLEMS OF LOW-VALUE NORTHERN HARDWOODS. Pulp and Paper Mag. of Canada, Woodlands Rev. pp. 36-39, illus.

(Forest management of deteriorated northern hardwood forests can be improved by finding an economically feasible means of harvesting the low-quality material. If raw material from stands can be reduced to some homogeneous form early in the harvesting stage, then costs can be reduced substantially. A design of a proposed mechanized system is presented to show the feasibility of converting pulpwood and low-value roundwood into usable chips.)

R-380 \*

Neetzel, John R.

BUILDING BETTER FARM FENCES. Univ. Minn. Ext. Bul. 272, 16 pp., illus. (Rev. 1964).

(This revision of a 1953 publication contains essentially all the original material on how to build a farm fence plus new sections on subjects such as gates, zigzag fencing, fence-row burning, and maintenance. Includes several pictures of experimental fence units after 8 to 12 years of service. Material is based largely on the cooperative study conducted by the Lake States Forest Experiment Station and the School of Forestry, University of Minnesota.)

R-381

Otis, C. K., and Neetzel, J. R.

INSULATING WALLS OF POLE FRAME BUILDINGS. Minn. Farm & Home Sci. 21(2): 12-13, illus.

(Describes cooperative studies by the School of Forestry and Agricultural Engineering of the University of Minnesota and the Lake States Forest Experiment Station on ways of insulating pole-frame farm buildings to create better living conditions and more efficient use of feed for birds and animals. Also describes some of the methods and gives some early results.)

RN-LS-41 \*

Ward, James C., and Marden, Richard M.

SUGAR MAPLE VENEER LOGS SHOULD BE GRADED FOR PITH FLECKS. U.S. Forest Serv. Res. Note LS-41, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Pith flecks caused by the mining of Agromyzid (Diptera) fly larvae frequently occur in Lake States sugar maple. Although sugar maple logs are not now graded for these pith flecks, the results of a small mill study cutting 1/16-inch-face veneers indicate that decided economic advantages can result from the development of an adequate grading technique.)



## Forest Recreation

Lucas, Robert C.

RP-LS-15 \*

THE RECREATIONAL CAPACITY OF THE QUETICO-SUPERIOR AREA. U.S. Forest Serv. Res. Paper LS-15, 34 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Capacity--the number of visitors and their degree of satisfaction--seems to be more a function of attitudes than physical factors. Total use appears close to capacity, but more areas are underused than overused. If past use trends continue, severe overuse will occur within 10 years or less.)

Lucas, Robert C.

RP-LS-8 \*

RECREATIONAL USE OF THE QUETICO-SUPERIOR AREA. U.S. Forest Serv. Res. Paper LS-8, 50 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(During summer 1961, about 72,000 people visited the Boundary Waters Canoe Area for an average stay of 4.4 days. Canoeists were the largest group. Maps of each use showed very uneven distributions. Nearness to Canada seemed most important of the factors related to use concentrations. Visits have been climbing rapidly; canoeing seems likely to increase most in the future.)

Lucas, Robert C.

R-347 \*

STATUS OF RECREATION RESEARCH RELATED TO USERS. Soc. Amer. Foresters Proc. 1963: 127-130.

(Recreational use projections merit only limited confidence, but there is agreement that wilderness use will likely grow faster than other types. User attitudes are diverse, often an array of minority views, many conflicting. Flexibility in planning and retention of opportunities for back-country recreation seem indicated. Five more neglected topics are discussed.)

Lucas, Robert C.

R-340 \*

WILDERNESS PERCEPTION AND USE: THE EXAMPLE OF THE BOUNDARY WATERS CANOE AREA. Natural Resources Jour. (Pub. by Univ. of New Mex.) 3: 394-411, illus.

(Definitions of wilderness have varied over time and between observers. In the Boundary Waters Canoe Area different views of the resource were held by administrators than by visitors. Major types of recreationists differed further. These views of the resource seem to influence its use and also suggest some management policies.)

Lucas, Robert C.

R-377

WILDERNESS--USER CONCEPTS. Naturalist 15(4): 22-29, illus. (Reprinted with slight revisions from Western Resources Conf. Papers, Univ. of Colo. Press, Boulder; to be published in January 1965.)

(Historical shifts in wilderness definitions are large and not necessarily ended. Wilderness policy needs to consider users' concepts of wilderness. Greater diversity and the addition of semi-wilderness management categories are suggested.)



Lucas, Robert C., and Priddle, George B.

ENVIRONMENTAL PERCEPTION: A COMPARISON OF TWO WILDERNESS AREAS. (Abs.) Assoc. of Amer. Geographers Annals 54: 428-429.

(Algonquin Provincial Park, Ontario, and the Quetico-Superior Area of Minnesota and Ontario are both wilderness lakelands. Studies of visitors to each area revealed essentially parallel views of the resources and their use. Both areas face similar problems of overuse and use conflicts, but those in Algonquin are more serious.)



6  
5  
1965

# List of Publications

LAKE STATES FOREST  
EXPERIMENT STATION

**NORTH CENTRAL FOREST EXPERIMENT STATION**

D. B. King, Director

**FOREST SERVICE**

**U. S. DEPARTMENT OF AGRICULTURE**

March 1966

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EXPERIMENT STATION



## FOREWORD

Listed here are Lake States Forest Experiment Station publications for 1965. The titles and annotations indicate the types of problems we are working on; the publications listed describe progress made on many of the approximately 200 individual studies underway in 28 forestry problem areas selected as most urgent.

This list completes all Lake States publications series. Beginning January 1, 1966, results of our research will be released under our new name — North Central Forest Experiment Station.

As one of several reorganizational moves recently taken by the Forest Service, U.S. Department of Agriculture, the area served by the old Lake States Station has been enlarged to include all Federal forestry research in Indiana, Illinois, Iowa, and Missouri, as well as in Michigan, Wisconsin, and Minnesota. The reorganization was designed to strengthen program administration and to achieve greater efficiency in use of research manpower and funds. We move forward into the new year with determination that these efficiencies will be reflected in greater output of research results during the year ahead to help overcome problems of the forest-land managers and the producers, processors, and consumers of forest products in our new 7-state area.



# LIST OF PUBLICATIONS DURING 1965

## LAKE STATES FOREST EXPERIMENT STATION

(Copies of the asterisked (\*) items are available. Please ask for them by order number and send your requests to Director, North Central Forest Experiment Station, Forest Service - U.S. Department of Agriculture, St. Paul, Minnesota 55101.)

### / General Forestry /

Order No.

Lucas, Robert C.

R-425

REVIEW OF "LAND FOR AMERICANS," 141 pp., illus., 1963, Chicago: Rand McNalley & Co.; and "LAND AND WATER FOR RECREATION," 144 pp., 1963, Chicago: Rand McNalley & Co. (both books prepared by Marion Clawson for Resources for the Future Policy Background Series). Econ. Geography (Clark Univ.).

Quinney, Dean N.

R-426

REVIEW OF "LAW AND ECONOMIC GROWTH: THE LEGAL HISTORY OF THE LUMBER INDUSTRY IN WISCONSIN, 1836-1915" by James Willard Hurst, 946 pp., illus. Cambridge, Mass.: Harvard Univ. Press. Jour. Natural Resources 5: 187-189.

### / Regeneration, Stand Improvement, and Harvest Cuttings /

Arend, John L.

R-412

SELECTIVE HARDWOOD CONTROL WITH 4-AMINO-3-5-6-TRICHLOROPICOLINIC ACID. Northeast. Weed Control Conf. Proc. 19: 528-535.  
(Prescription rates are presented for controlling mixed hardwoods with stem injections of Tordon 22K, Tordon 101 mixture, and 2,4,5-T amine.)

Benzie, John W.

RN-LS-64\*

A TEST OF SEEDING DEPTH FOR JACK PINE AND RED PINE. U.S. Forest Serv. Res. Note LS-64, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.  
(Jack pine seedling establishment was not significantly increased by covering the seed, and it was greatly reduced when the seed was covered with more than 0.2 inch of soil. Covering red pine seed was beneficial, but the critical depth was between 0.4 and 0.6 inch.)

Benzie, John W.

R-419\*

COMMENTS ON DIRECT SEEDING IN THE LAKE STATES. In Direct Seeding in the Northeast. Univ. of Mass. Agr. Expt. Sta. Symposium Proc. p. 24.  
(Briefly summarizes direct seeding trials in the Lake States, the present status of direct seeding as a regeneration method, and some problems needing research attention.)

Clausen, Knud E.

RN-LS-69\*

YELLOW AND PAPER BIRCH SEEDS GERMINATE WELL AFTER FOUR YEARS OF STORAGE. U.S. Forest Serv. Res. Note LS-69, 2 pp. Lake States Forest Expt. Sta., St. Paul, Minn.  
(Seeds of yellow and paper birch stored in closed containers at 36° to 40° F. for 4 years germinated as well as or better than when fresh.)

\* Copies available.



Stoeckeler, J. H.

R-398\*

SOME SOIL AND OTHER SITE CONSIDERATIONS IN NURSERY SITE SELECTION FOR GROWING YOUR OWN STOCK FOR CHRISTMAS TREES. Amer. Christmas Tree Growers Jour. IX(1): 14-20, illus.

(Discusses the major factors that affect nursery site selection, such as central location, soil texture, fertility, water quality, weed problems, mycorrhizal inoculation, wind protection, and protection against mammals.)

Stoeckeler, Joseph H.

R-395\*

SPRING FROST DAMAGE IN YOUNG FOREST PLANTINGS NEAR LA CROSSE, WIS. Jour. Forestry 63: 12-14, illus. Also in Amer. Christmas Tree Growers' Jour. 9(2): 36, 38-40, illus.

(Observations of effects of spring freezing of May 22-23, 1963, on 13 tree species in second- and third-year plantations near La Crosse, Wis., indicate the following sensitivity to frost injury: very sensitive--black walnut, white ash, and red oak; moderately sensitive--Norway spruce, white spruce, European larch; slightly sensitive--Austrian pine; not sensitive--jack, ponderosa, red, Scotch, and white pines and eastern redcedar. Some variation was noted in frost damage by altitude.)

Stoeckeler, Joseph H., and Slabaugh, Paul E.

AH-279\*

CONIFER NURSERY PRACTICE IN THE PRAIRIE-PLAINS. U.S. Dept. Agr., Agr. Handbook 279, 93 pp., illus.

(Covers many aspects of large-scale production of conifer nursery stock for windbreak and afforestation planting under Great Plains conditions, including seed collection and its handling, seeding, transplanting, soil management, and pest control.)

#### / Tree Improvement and Physiology /

Conley, William T.; Dawson, David H.; and Hill, Robert B.

RN-LS-71\*

THE PERFORMANCE OF EIGHT SEED SOURCES OF PONDEROSA PINE IN THE DENBIGH EXPERIMENTAL FOREST, NORTH DAKOTA. U.S. Forest Serv. Res. Note LS-71, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(The data strongly indicate that different geographic races of ponderosa pine do exist in the eastern outliers of the species, and that eastern Montana sources may be the best adapted to the northern Great Plains environment.)

Dawson, David H.

R-427

A SEED SOURCE STUDY OF PONDEROSA PINE FOR THE GREAT PLAINS REGION. In Fourth Central States Forest Tree Improvement Conf. Proc. (1964): 38-41, publ. by Nebr. Agr. Expt. Sta., Lincoln.

(Reports on the development and progress to date of a Plains-wide ponderosa pine seed source variation study involving nursery and field testing of 80 seed sources.)

Haissig, Bruce E.

R-423\*

ORGAN FORMATION IN VITRO AS APPLICABLE TO FOREST TREE PROPAGATION. Bot. Rev. 31: 607-626.

(Literature concerning the influences of auxins, adenine, kinetin, light, heat, time, age, and physical characteristics of the medium on in vitro organ formation by sterile seed-plant fragments is reviewed and integrated.)

\* Copies available.



King, James P.

SEED SOURCE X ENVIRONMENT IN INTERACTIONS IN SCOTCH PINE.

I. HEIGHT GROWTH. *Silvae Genet.* 14: 105-115, illus.

(Describes 3- and 4-year height growth of 55 Scotch pine seed sources growing in test plantations in Michigan and Illinois. Some causes and consequences of the seed source x environment interactions are discussed.)

R-429

King, James P.

SEED SOURCE X ENVIRONMENT INTERACTIONS IN SCOTCH PINE.

II. NEEDLE LENGTH AND COLOR. *Silvae Genet.* 14: 141-185, illus.

(Describes needle length and color of 55 Scotch pine seed sources growing in test plantations in Michigan. The effect of seed source x environment interactions on a selection program is also discussed.)

King, James P.; Nienstaedt, Hans; and Macon, John.

RN-LS-66\*

SUPER-SPRUCE SEEDLINGS SHOW CONTINUED SUPERIORITY. *U.S. Forest*

*Serv. Res. Note* LS-66, 2 pp. Lake States Forest Expt. Sta.,

St. Paul, Minn.

(White spruce seedlings, selected for superior nursery performance, have maintained their height growth advantage over average 2-2 nursery stock after seven growing seasons in the field. The "super-spruce" also show less damage from late spring frost than the average stock.)

R-430\*

Larson, Philip R.

STEM FORM OF YOUNG LARIX AS INFLUENCED BY WIND AND PRUNING. *Forest*

*Sci.* 11: 412-424, illus.

(Removal of live crown by drastic pruning favored growth of the upper stem and decreased growth on the lower stem, whereas exposure to wind caused a pronounced downward shift of increment towards the stem base, most generally at the expense of upper stem parts.)

R-431

Nienstaedt, Hans.

GRAFTING NORTHERN CONIFERS WITH SPECIAL REFERENCE TO WHITE SPRUCE.

In: *U.S. Forest Serv. Region 9 Nurserymen's Conf. Proc.* (1965):

41-45.

(Presents a brief general treatment of grafting methods; states that grafting of white spruce can be extended over practically the entire year; discusses the organization of grafting crews and output.)

R-432

Nienstaedt, H.

RED PINE PROGENY TESTS, 1931 AND 1933 MINNESOTA PLANTINGS. In *Com.*

on *Forest Tree Breeding in Canad. Proc.*, September 16-18, 1964:

151-156. (n.d., circa 1965)

(Discusses the results of individual tree progeny tests established 1931 and 1933 with open-pollinated seed from 69 individual tree collections; indicates that the differences in height and diameter growth and survival of the progenies were all significant at the 1-percent level; expresses the view that, even though variation in red pine is comparatively smaller than in other northern conifers, an improvement program in red pine would be profitable; and recommends economic evaluations of such programs.)

\* Copies available



Rudolf, P. O.

SOME EVIDENCE OF RACIAL VARIATION IN RED PINE (PINUS RESINOSA AIT.).  
In Com. of Forest Tree Breeding in Canad. Proc. 9 (Part II): 143-149.  
(n.d., circa 1965)

(Presents evidence, based primarily on the Lake States Forest Experiment Station field trials of 1931 and 1933, to indicate that while red pine is an unusually uniform species genetically, there is a pattern of variation in survival and growth over its range within the United States. Sources from Central Wisconsin, Lower Michigan, and the Northeast responded differently than those from other parts of the Lake States in northeastern Minnesota.)

R-434\*

Rudolf, Paul O.

AVAILABILITY OF TREE SEED TESTING IN THE UNITED STATES--1964. Tree Planters Notes 73: 12-14.

(Based on contacts with all State seed testing laboratories in the United States, presents a list showing which ones now test tree seeds and which ones would be willing to do so. Also includes reference to some private seed testing laboratories.)

R-435

Rudolf, Paul O.

THE CERTIFICATION OF FOREST TREE SEEDS. U.S. Forest Serv. Region 9 Nurserymen's Conf. Proc. (1965): 24-33.

(Provides some background to development of forest tree seed certification activities in the United States, and describes the current situation in the United States and internationally as of 1965.)

R-433\*

Rudolf, Paul O.

STATE TREE SEED LEGISLATION. Tree Planters Notes 72: 1-2.

(A brief statement on State seed laws as they pertain to tree seed indicated that 13 States have such legislation as of 1965.)

R-436

Rudolf, Paul O.

A TECHNICAL DISCUSSION OF THE "DRAFT OECD SCHEME FOR THE CONTROL OF FOREST REPRODUCTIVE MATERIAL MOVING IN INTERNATIONAL TRADE." In Internatl. Crop Impr. Assoc. Ann. Rpt. 46: 99-102. (Published in 1964)

(The second revision of the scheme for the control of forest reproductive material moving in international trade, as developed by a committee appointed by the Organization for Economic Cooperation and Development, seemed generally agreeable to United States foresters. A few suggestions for revision and clarification were presented.)

R-437

Rudolf, Paul O.

TREE SEED CERTIFICATION PROGRESS IN THE UNITED STATES. In Internatl. Crop Impr. Assoc. Ann. Rpt. 46: 95-99. (Published in 1964)

(Based on a survey of all agencies known to be engaged in tree seed certification activities in the United States, it appeared that as of the end of 1964 six States made legal provision for tree seed certification activities. Their standards generally were similar to the minimum standards approved by the International Crop Improvement Association.)



Heinselman, M. L.

R-399\*

STRING BOGS AND OTHER PATTERNED ORGANIC TERRAIN NEAR SENEY, UPPER MICHIGAN. Ecology 46: 185-188.

(Treeless string bogs and topographically oriented strips of bog forest have been discovered near Seney, Mich., lat. 46° 15'N, perhaps the southern limit of patterned bogs on the North American continent. Patterned ground has developed through paludification of a sandplain dotted with extinct dunes and sloping about 8 feet per mile. The principles that can explain the patterns and bog-forming processes at Seney may apply to large areas of forested and treeless peatland.)

Heinselman, Miron L.

R-438

TOPOGRAPHY, STRATIGRAPHY, AND VEGETATION PATTERNS OF A RAISED BOG IN THE LAKE AGASSIZ PEATLANDS NATURAL AREA. (Abs.) Ecol. Soc. Amer. Bul. 45(3): 93, 94. (Published in 1964)

Jacobs, Rodney D.

RN-LS-57\*

SEASONAL HEIGHT GROWTH PATTERNS OF SUGAR MAPLE, YELLOW BIRCH, AND RED MAPLE SEEDLINGS IN UPPER MICHIGAN. U.S. Forest Serv. Res. Note LS-57, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Seasonal height growth patterns of sugar maple, red maple, and yellow birch growing at Dukes, Mich., follow closely the patterns of these species reported elsewhere. Sugar maple makes rapid early growth but has a very short season; 90 percent of its height growth is completed in less than 20 days. Yellow birch has a later acceleration but a longer season--50 to 60 days. Red maple follows a course midway between the two. The growing period for sugar maple here was the shortest found in the literature.)

Roe, Eugene I.

R-439

REVIEW OF "POTENTIAL NATURAL VEGETATION OF THE CONTERMINOUS UNITED STATES" by A. W. Kuchler, 116 pp., illus., map. 1964. Amer. Geog. Soc. Spec. Publ. 36, New York. Forest Sci. 11: 325.

Rudolf, Paul O.

RN-LS-74\*

BOTANICAL AND COMMERCIAL RANGE OF BLACK SPRUCE IN THE LAKE STATES. U.S. Forest Serv. Res. Note LS-74, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(The botanical and commercial ranges of black spruce are described in the text and illustrated by maps. A supplemental map shows the location of native specimens, based on established herbarium records, forest survey plot data, and similar reliable records. Commercial occurrence is indicated for each county that has at least 1,000 cords of black spruce on commercial forest land.)

Rudolf, Paul O., and Andresen, John W.

RN-LS-63\*

BOTANICAL AND COMMERCIAL RANGE OF EASTERN WHITE PINE IN THE LAKE STATES. U.S. Forest Serv. Res. Note LS-63, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(The botanical and commercial ranges of eastern white pine are described in the text and illustrated by maps. A supplemental map shows the location of native specimens, based on established herbarium records, forest survey plot data, and similar reliable records. Commercial occurrence is indicated for each county that has at least 1,000 cords of white pine on commercial forest land.)

\* Copies available.



Rudolf, Paul O., and Andresen, John W.

RN-LS-62\*

BOTANICAL AND COMMERCIAL RANGE OF RED PINE IN THE LAKE STATES. U.S. Forest Serv. Res. Note LS-62, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(The botanical and commercial ranges of red pine are described in the text and illustrated by maps. A supplemental map shows the location of native specimens, based on established herbarium records, forest survey plot data, and similar reliable records. Commercial occurrence is indicated for each county that has at least 1,000 cords of red pine on commercial forest land.)

Rudolf, Paul O., and Andresen, John W.

RN-LS-73\*

BOTANICAL AND COMMERCIAL RANGE OF WHITE SPRUCE IN THE LAKE STATES. U.S. Forest Serv. Res. Note LS-73, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(The botanical and commercial ranges of white spruce are described in the text and illustrated by maps. A supplemental map shows the location of native specimens, based on established herbarium records, forest survey plot data, and similar reliable records. Commercial occurrence is indicated for each county that has at least 1,000 cords of white spruce on commercial forest land.)

Tubbs, Carl H.

RN-LS-72\*

INFLUENCE OF TEMPERATURE AND EARLY SPRING CONDITIONS ON SUGAR MAPLE AND YELLOW BIRCH GERMINATION IN UPPER MICHIGAN. U.S. Forest Serv. Res. Note LS-72, 2 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Documents ability of sugar maple to germinate under a snow cover, and indicates variations in temperature requirements for germination of sugar maple and yellow birch.)

Watt, Richard F.

R-440

FOLIAR ANALYSES OF BLACK SPRUCE IN BOGS OF GLACIAL LAKE AGASSIZ, MINNESOTA, INDICATE DEFICIENCY OF NITROGEN AND PHOSPHORUS. (Abs.) Ecol. Soc. Amer. Bul. 45(3): 86-87. (Published in 1964)

(Analysis of black spruce foliage for 12 elements indicated that nitrogen and phosphorus percentages decreased along a gradient from high to low site quality; potassium was inversely related to site index. Fertilization of poor site with nitrogen and phosphorus increased height growth of black spruce by 400 percent. The response to either element applied singly was less but significant, confirming the foliar diagnosis. Dry weight production of the ericaceous vegetation increased under fertilization; much of the sphagnum cover was killed.)

Watt, Richard F., and Heinselman, M. L.

R-408\*

FOLIAR NITROGEN AND PHOSPHORUS LEVELS RELATED TO SITE QUALITY IN A NORTHERN MINNESOTA SPRUCE BOG. Ecology 46: 357-361, illus.

(Foliar analysis for 12 elements along a steep site gradient from good "water track" site to poor sphagnum-black spruce site indicated that only nitrogen and phosphorus decreased with site index. Higher site quality in and adjacent to the water track may be a result of nitrogen fixation by the alder stand in this area, more rapid decomposition of organic matter, and movement of minerally enriched water from an adjacent "island" of mineral soil.)

\* Copies available.



/ Shelterbelts /

Slabaugh, P. E.

R-403\*

A REAPPRAISAL OF SOME SILVICULTURAL PROBLEMS OF GREAT PLAINS WINDBREAKS.  
Soc. Amer. Foresters Proc. 1964: 23-27.

(Reviews considerations involved in the establishment of shelterbelts and silvicultural problems that have arisen in established plantings. Discusses the practices of thinning, pruning, rehabilitation, and renewal, and lists some new developments in Plains forestry.)

Stoeckeler, J. H.

R-404\*

THE DESIGN OF SHELTERBELTS IN RELATION TO CROP YIELD IMPROVEMENT.  
World Crops 17(1): 27-32, illus.

(Discusses various aspects of Great Plains shelterbelts, particularly number of rows, orientation, species composition, interval between shelterbelts, and life span of shelterbelts in relation to crop yields, especially small grains. Relative response of many other crops to shelterbelt protection is cited.)

/ Soils and Water /

Boelter, D. H.

R-420\*

HYDRAULIC CONDUCTIVITY OF PEATS. Soil Sci. 100: 227-231.

(Hydraulic conductivities of peats measured by field methods are significantly lower than those measured by laboratory methods and presumably represent the condition in the organic soil more accurately. Hydraulic conductivities were found to range from about  $3810 \times 10^{-5}$  cm./sec. for undecomposed moss peats in or near surface horizons to  $0.75 \times 10^{-5}$  cm./sec. for dense decomposed and herbaceous peats.)

Sartz, Richard S.

RN-LS-59\*

EFFECT OF FOREST LITTER ON GROWTH OF HARDWOOD SEEDLINGS. U.S. Forest Serv. Res. Note LS-59, 2 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Red and white oak and black walnut seedlings grew much faster on lysimeters that had a covering of leaf litter than on a lysimeter without litter. The third year after treatment the mulched black walnut, red oak, and white oak averaged 55 percent, 51 percent, and 40 percent taller, respectively. The faster growth probably resulted from a greater supply of available moisture.)

Sartz, Richard S.

R-441

FORESTRY RESEARCH TO BENEFIT TROUT? Wis. Conserv. Bul. 30(2): 20-21, illus.

(This popular-style article explains how land use, through its effect on infiltration and soil freezing, can influence flood runoff and the base flow of streams, both key factors in trout stream management. By better defining the effects of different tree species and cutting patterns, forestry research can benefit trout.)

Stoeckeler, J. H.

RN-LS-70\*

FROST PENETRATION AND TRAFFICABILITY IN TWO TYPES OF PEAT AS AFFECTED BY TREATMENT OF SNOWPACK AND SURFACE MOSSES. U.S. Forest Serv. Res. Note LS-70, 4 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Presents data on the rate of freezing in a sphagnum peat and a woody peat under conditions of undisturbed snow, packed snow, and snow removed. The rate of freezing and trafficability for vehicles in winter logging are related to degree days below freezing.)

\* Copies available.



Stoeckeler, Joseph H.

DRAINAGE ALONG SWAMP FOREST ROADS; LESSONS FROM NORTHERN EUROPE.

Jour. Forestry 63: 772-776, illus.

(Cites hydrological problems that may be created when roads cross peatlands and other wet mineral soils. A rise in water table often occurs at many wetland crossings, and timber is killed or its growth rate depressed unless culverts are set sufficiently deep and a collector ditch and discharge ditch of adequate length are provided.)

R-442

Striffler, W. David.

SUSPENDED SEDIMENT CONCENTRATION IN A MICHIGAN TROUT STREAM AS RELATED TO WATERSHED CHARACTERISTICS. In Fed. Inter-Agency Sedimentation Conf. Proc., 1963, U.S. Dept. Agr. Misc. Pub. 970: 144-150.

(Relates sediment production from within a number of sample watersheds in the Tobacco River Watershed to soils, geology, land use, and other watershed characteristics. Of the 28 independent variables examined, 7 were shown to be significant at the 5-percent level or better. These included stream discharges, whether the stream was rising or falling, eroding banks, and various soil and land use variables. The high significance of eroding banks throughout the analysis suggests that stabilization practices might significantly reduce stream sediment concentration.)

# / Insects /

R-400\*

Miller, William E.

NUMBER OF BRANCHLETS ON RED PINE IN YOUNG PLANTATIONS. Forest Sci.

11: 42-49, illus.

(Develops regression equations for rapidly estimating current numbers of branchlets or tips on young trees, also usable for reconstructing past numbers and forecasting future numbers. Some aspects of yearly multiplication of branchlet numbers are also explored.)

R-413\*

Miller, William E.

PINE TIP MOTHS IN CENTRAL AMERICA. Turrialba; Revista Interamericana de Ciencias Agricolas 15(1): 58.

(Records the presence of the subtropical pine tip moth (*Rhyacionia subtropica* Miller) in Central America, and points out that *R. pseudostrobana* Amsel, listed earlier from Guatemala, is in reality a misnomer for the well-known Nantucket pine moth (*R. frustrana* (Comstock)).)

R-424\*

Miller, William E.

PROTECTING CHRISTMAS TREE PLANTATIONS. Jour. Forestry 63: 849-852.

(Fire, vertebrate, insect, and pathogenic disease hazards to major Christmas tree species are surveyed, together with remedies. Limited information suggests that Christmas tree quality can be profitably improved through a higher level of protection.)

R-418\*

Millers, Imants, and Wilson, Louis F.

SUPPRESSION OF THE SARATOGA SPITTLEBUG, *APHROPHORA SARATOGENSIS* (FITCH), WITH MALATHION IN MICHIGAN PINE PLANTATIONS. Jour. Econ. Ent. 58(5): 942-944.

(Malathion was tested as a substitute for DDT to control the spittlebug. Applications by mistblower showed that 1/2 lb. malathion/gal./acre controlled the adults as well as 1 lb. DDT/gal./acre.)

\* Copies available.



Wilson, Louis F.

EUROPEAN PINE SAWFLY. Forest Pest Leaflet 98, 8 pp., illus.

(Briefly discusses the hosts, range, and injury of this defoliating insect in pine plantations; describes its history, habits, and stages; and discusses biological and chemical control recommendations.)

R-422\*

Wilson, Louis F.

LIFE HISTORY AND SOME HABITS OF THE PINE GALL WEEVIL, PODAPION GALLICOLA RILEY, IN MICHIGAN. Canad. Entomol. 97: 962-969, illus.

(The weevil has a 3-year life cycle on red pine in Michigan. Adults lay eggs in the bark from June to August. Larvae emerge in August and feed in the bark and then in the xylem. Head capsule measurements indicate three larval instars. Gall development begins early the second year shortly after larvae reach the second instar. Third instars appear the third year, and pupae early the fourth season. Adults emerge in June of the fourth season; they do not overwinter. Apparently three distinct broods occur in Michigan.)

FPL-39\*

Wilson, Louis F., and Schmiede, Donald C.

PINE ROOT COLLAR WEEVIL. U.S. Forest Serv. Forest Pest Leaflet 39 Rev., 7 pp., illus.

(Briefly discusses the hosts, range, and injury of this insect in pine; indicates similar and associated insects; describes its life history, habits, and stages; and discusses methods of population survey and silvicultural and chemical control recommendations.)

#### / Diseases /

R-406\*

Anderson, Gerald W.

THE DISTRIBUTION OF EASTERN AND WESTERN GALL RUSTS IN THE LAKE STATES. Plant Dis. Rptr. 49: 527-528, illus.

(Eastern and western gall rust distributions were sampled on jack pine in Minnesota, Wisconsin, and Michigan. Western gall rust predominated in the northern areas, and eastern gall rust occurred primarily in the south. Both fungi were found in all three States.)

R-397\*

Anderson, Gerald W., and French, David W.

DIFFERENTIATION OF CRONARTIUM QUERCUM AND CRONARTIUM COLEOSPORIOIDES ON THE BASIS OF AECIOSPORE GERM TUBES. Phytopathology 55: 171-173, illus.

(When germinated on 2-percent water agar at 18.5° C., Cronartium quercum aeciospores produce germ tubes which are longer than those produced by C. coleosporioides (Peridermium harknessii). They also have more tendency to produce distal branches and to lyse within 24 hours.)

R-407\*

Anderson, Gerald W., and French, David W.

WESTERN GALL RUST IN THE LAKE STATES. Forest Sci. 11: 139-141, illus.

(Western gall rust, Cronartium coleosporioides Arth. (Peridermium harknessii J. P. Moore), was found in jack pine (Pinus banksiana Lamb.) in the area. Jack pine seedlings and Indian paintbrush (Castilleja coccinea L.) both were successfully inoculated with aeciospores.)



- Anderson, Neil A., and Anderson, Ralph L. RN-LS-56\*  
 THE SUSCEPTIBILITY OF JACK PINE AND LODGEPOLE PINE AND THEIR  
 HYBRIDS TO SWEETFERN RUST AND EASTERN GALL RUST. U.S. Forest Serv.  
 Res. Note LS-56, 4 pp. Lake States Forest Expt. Sta., St. Paul, Minn.  
 (Presents evidence indicating that lodgepole pine and lodgepole-  
 jack pine hybrids are more susceptible to sweetfern rust and eastern  
 gall rust than is the local jack pine.)
- Kessler, Kenneth J., Jr. R-405\*  
 DIEBACK OF MANAGED, OLD-GROWTH NORTHERN HARDWOODS IN UPPER MICHIGAN,  
 1954-1964--A CASE HISTORY. Plant Dis. Rptr. 49: 483-486, illus.  
 (A dieback survey of northern hardwoods on 212 one-fifth acre  
 plots in a managed old-growth forest indicated that dieback of all  
 species increased during 1958 to 1962. A recovery trend began in  
 1963. Most seriously injured was yellow birch followed by beech,  
 red maple, and sugar maple in that order.)
- Kessler, Kenneth J., Jr., and Ohman, John H. R-409\*  
 CRYPTOSTROMA CORTICALE--ALLERGEN, PLANT PATHOGEN, SAPROPHYTE.  
 Phytopath. 55: 811-812.  
 (Recent observations on the fungus, the cause of maple bark  
 disease which is a serious human allergy, are reported, the medical  
 literature reviewed, and the importance of the fungus in wood-using  
 industries is discussed.)
- Nicholls, T. H., Van Arsdel, E. P., and Patton, R. F. RN-LS-58\*  
 RED PINE NEEDLE RUST DISEASE IN THE LAKE STATES. U.S. Forest Serv.  
 Res. Note LS-58, 4 pp., illus. Lake States Forest Expt. Sta.,  
 St. Paul, Minn.  
 (Presents evidence suggesting that there are at least three  
 forms of the pine needle rust, Coleosporium asterum, in the Lake  
 States. The form on red and jack pine infects goldenrod but not  
 asters.)
- Skilling, Darroll. R-446  
 ROOT ROT ON CONIFERS IN THE LAKE STATES. U.S. Forest Serv. Region 9  
 Nurserymen's Conf. (1965): 4-11.  
 (Discusses symptoms and control for Cylindrocladium root rot in  
 nurseries; describes present status of knowledge on Scleroderris  
 canker in red and jack pine plantations.)
- Van Arsdel, E. P. R-415\*  
 MICROMETEOROLOGY AND PLANT DISEASE EPIDEMIOLOGY. Phytopathology 55:  
 943-952, illus.  
 (Summarizes present status of knowledge concerning the influence  
 of microclimate on disease development. Snow mold, white pine blister  
 rust, and rice blast are discussed as specific examples of known  
 relationships.)
- Van Arsdel, E. P. RN-LS-60\*  
 RELATIONSHIPS BETWEEN NIGHT BREEZES AND BLISTER RUST SPREAD ON LAKE  
 STATES WHITE PINES. U.S. Forest Serv. Res. Note LS-60, 4 pp., illus.  
 Lake States Forest Expt. Sta., St. Paul, Minn.  
 (Presents evidence suggesting that night air movements, as  
 influenced by topography, tree cover, and the presence of lakes, have  
 a strong influence on the dissemination pattern of blister rust spores.)

\* Copies available.



/ Fire /

Brown, James K.

RP-LS-20\*

ESTIMATING CROWN FUEL WEIGHTS OF RED PINE AND JACK PINE. U.S. Forest Serv. Res. Paper LS-20, 12 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Shows the effect of site, age, and stand density on crown size of individual red pine and jack pine trees and provides a method of estimating crown fuel weights.)

R-402\*

Buckman, R. E.

SILVICULTURAL USE OF PRESCRIBED BURNING IN THE LAKE STATES. Soc. Amer. Foresters Proc. 1964: 38-40, illus.

(Prescribed burning is only now emerging as a silvicultural tool in the Lake States. Four major uses of fire are under development: Jack pine regeneration with seed trees; black spruce regeneration on organic soil; understory control beneath fire-resistant red and white pine; and preparation of planting and seeding sites following clearcutting.)

R-396\*

Buckman, Robert E., and Blankenship, Lytle H.

REPEATED SPRING PRESCRIBED BURNING REDUCES ABUNDANCE AND VIGOR OF ASPEN ROOT SUCKERING. Jour. Forestry 63: 23-25, illus.

(Presents the 6-year results of a prescribed burning study in northern Minnesota. Two or more spring burns reduce the abundance and vigor of suckering by quaking aspen, but not that of most shrubs and other hardwoods.)

/ Mensuration /

Lundgren, Allen L.

RN-LS-67\*

ALINEMENT CHART FOR NUMBERS OF TREES--DIAMETERS--BASAL AREAS. U.S. Forest Serv. Res. Note LS-67, 2 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Presents a chart that eliminates or simplifies many calculations involving relationships among numbers of trees, diameters, and basal areas. If any two of these variables are known or can be estimated, the other can be found. Some examples of its use are given.)

/ Economics /

Lundgren, Allen L.

RP-LS-18\*

THINNING RED PINE FOR HIGH INVESTMENT RETURNS. U.S. Forest Serv. Res. Paper LS-18, 20 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Under almost any conditions investment returns are highest if red pine stands are thinned regularly to 90 square feet of basal area per acre rather than to a higher basal area density. Financial rotations vary widely with stand conditions, investment alternatives, costs, and prices.)

RP-LS-17\*

Schallau, Con H.

FRAGMENTATION, ABSENTEE OWNERSHIP, AND TURNOVER OF FOREST LAND IN NORTHERN LOWER MICHIGAN. U.S. Forest Serv. Res. Paper LS-17, 12 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Examines size of tract, residence of owner, and turnover rate of forest properties in northern Lower Michigan. Explains postwar fragmentation and land ownership trends.)

\* Copies available.



Wambach, R. F., and Lundgren, A. L.

R-417\*

THE IMPORTANCE OF SITE QUALITY IN RED PINE. Mich. Acad. Sci., Arts, and Letters Papers L(1964): 67-74, illus.

(Presents data which illustrate the impact of site quality on physical and economic yield of red pine in the Lake States. Site quality has a relatively greater influence on financial return than has initial stocking, thinning regime, or rotation length. We can do more to assure a favorable return on our timber-growing investment by concentrating on our best sites than by refining practices on poor sites.)

/ Resource and Production Statistics /

DeBald, Paul S., and Gansner, David A.

RN-CS-25\*

TIMBER VOLUME IN ILLINOIS, 1962. U.S. Forest Serv. Res. Note CS-25, 6 pp., illus. Central States Forest Expt. Sta., Columbus, Ohio. (Published in 1964)

(Presents the 1962 volumes of growing stock and sawtimber for softwoods and hardwoods in Illinois by counties, and analyzes changes in growing stock and sawtimber volumes by species between 1948 and 1962.)

Essex, Burton L., and Gansner, David A.

RB-LS-3\*

ILLINOIS' TIMBER RESOURCES. U.S. Forest Serv. Resource Bul. LS-3, 56 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Presents statistics on forest area, timber volumes, and growth for Illinois in 1962 with comparisons to those for 1948. Indicates the level of timber cutting. Examines trends of change during recent years and projects cut and growth to 1992.)

Gansner, David A., and Chase, Clarence D.

RB-CS-3\*

KENTUCKY FORESTS, SOUTHERN CUMBERLAND UNIT. U.S. Forest Serv. Resource Bul. CS-3, 37 pp., illus. Central States Forest Expt. Sta., Columbus, Ohio.

(Presents forest area, timber volume, and growth information for 1963 in a 12-county area in southeastern Kentucky. Presents timber industry and timber cut information for 1962 and the annual desirable cut for the next decade. Discusses trends since 1949.)

Gansner, David A., and Knutson, Robert G.

RN-CS-24\*

KENTUCKY PRODUCES 466 million board feet of lumber in 1962. U.S. Forest Serv. Res. Note CS-24, 4 pp., illus. Central States Forest Expt. Sta., Columbus, Ohio. (Published in 1964)

(Shows 1962 lumber production by species and county, and the trend of lumber production in the State since 1899.)

Horn, Arthur G.

RB-LS-2\*

PULPWOOD PRODUCTION IN LAKE STATES COUNTIES, 1964. U.S. Forest Serv. Resource Bul. LS-2, 19 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Shows pulpwood production for 1964 by counties and species for each of the Lake States and compares production by species and Forest Survey District for several previous years.)

\* Copies available.



Horn, Arthur G.

LAKE STATES PULPWOOD PRODUCTION LEVELS OFF--1964. U.S. Forest Serv. Res. Note LS-65, 2 pp. Lake States Forest Expt. Sta., St. Paul, Minn.

(Indicates the trend of pulpwood production compared to previous years and shows the 1964 pulpwood production by species and destination of wood produced in each of the three Lake States. Also shows imports from other States and Canada.)

Office of Iron Range Resources and Rehabilitation (Minnesota) and Lake States Forest Experiment Station.

**TIMBER RESOURCES OF MINNESOTA:**

AITKIN COUNTY, 1961, 24 pp., illus. (Published in 1964)  
 BECKER COUNTY, 1961, 24 pp., illus. (Published in 1964)  
 BELTRAMI COUNTY, 1961, 24 pp., illus. (Published in 1964)  
 CASS COUNTY, 1961, 24 pp., illus. (Published in 1964)  
 CLEARWATER COUNTY, 1961, 23 pp., illus. (Published in 1964)  
 CROW WING COUNTY, 1961, 24 pp., illus. (Published in 1964)  
 HUBBARD COUNTY, 1961, 23 pp., illus. (Published in 1964)  
 ITASCA COUNTY, 1961, 24 pp., illus. (Published in 1964)  
 LAKE OF THE WOODS COUNTY, 1961, 24 pp., illus. (Published in 1964)  
 MAHNOMEN COUNTY, 1961, 20 pp., illus. (Published in 1964)  
 ROSEAU COUNTY, 1961, 20 pp., illus. (Published in 1964)  
 WADENA COUNTY, 1961, 20 pp., illus. (Published in 1964)

Published by the Office of Iron Range Resources and Rehabilitation. Copies are available at that office, St. Louis Court House, Room 220, Hibbing, Minn. 55746, and at the Office of Iron Range Resources and Rehabilitation, 60 State Office Bldg., St. Paul, Minn. 55101.

(Each County report presents estimates of forest area, ownership, timber volumes, forest industry, and the timber balance--growth, cut, and desirable cut.)

/ Marketing, Utilization, and Engineering /

RP-LS-21\*

Carpenter, E. M., and Quinney, D. N.

BALSAM FIR DIMENSION LUMBER IN SELECTED MINNESOTA MARKETS. U.S. Forest Serv. Res. Paper LS-21, 13 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(Investigates the present and potential market for balsam fir dimension lumber in Minneapolis-St. Paul and northern Minnesota; shows the present volumes of balsam fir in the northern Lake States and its current uses and physical characteristics; summarizes the types of customers and end uses for which lumber yards now sell or would expect to sell balsam fir dimension lumber; and suggests production and marketing techniques that could make it competitive with species from other areas.)

R-443

Erickson, John E. [R].

AN INVESTIGATION OF POWER REQUIREMENTS FOR CHIPPING HARDWOODS. Amer. Pulpwood Assoc. Quart. October 1964, p. 29. (Paper 64-47: (4.53)). (Published in 1964)

(Describes equipment and instrumentation for an investigation of power requirements for chipping hardwoods. Power requirements from preliminary tests are given. The study is being done in cooperation with the Mechanical Engineering Department of Michigan Technological University.)

\* Copies available.



Marden, Richard M.

R-410\*

A NEW APPROACH TO TREE GRADING FOR NORTHERN HARDWOODS. Forest Prod. Jour. 15: 179-184, illus.

(Describes techniques and interim results of an investigation to devise an accurate tree-grading system for sugar maple (Acer saccharum Marsh.) in the Lake States. Equations were calculated for estimating the value of standing trees by relating stem characteristics to product yields. Results indicate that accurate predictions of product grade yields are possible.)

/ Recreation and Wildlife /

Frissell, Sidney S., Jr., and Duncan, Donald P.

R-444

CAMPSITE PREFERENCE AND DETERIORATION IN THE QUETICO-SUPERIOR CANOE COUNTRY. Jour. Forestry 63: 256-260, illus.

(Canoeists showed strong preferences for campsites located in pine stands and for islands. Ground cover loss was high even on lightly used sites. Regression analysis indicated some of the factors related to site durability.)

King, David A.

R-416\*

SOME SOCIOECONOMIC COMPARISONS OF HURON AND MANISTEE NATIONAL FOREST FAMILY CAMPERS WITH MARKET POPULATIONS. Mich. Acad. Sci., Arts, and Letters Papers L(1964): 49-65, illus.

(The characteristics of camping families were compared with those of families in the Forests' market areas. Differences were found in income, education, and occupation. The results indicate an association between the characteristics and whether a family camped on the Forests. The comparisons suggest a short-term growth in camping, perhaps followed by a leveling off.)

King, David A.

RP-LS-19\*

CHARACTERISTICS OF FAMILY CAMPERS USING THE HURON-MANISTEE NATIONAL FORESTS. U.S. Forest Serv. Res. Paper LS-19, 11 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn.

(About 90 percent of the families camping on the Forests lived within a day's drive of them. The mixture of adults and children presents a problem in the development of interpretive programs. In terms of income, occupation, and education, the families are middle and upper-middle class. Many families were experienced campers but new to the Forests.)

Lucas, Robert C.

RN-LS-61\*

THE IMPORTANCE OF FISHING AS AN ATTRACTION AND ACTIVITY IN THE QUETICO-SUPERIOR AREA. U.S. Forest Serv. Res. Note LS-61, 3 pp. Lake States Forest Expt. Sta., St. Paul, Minn.

(Opinions concerning the importance of fishing as a Lake States recreational attraction vary. Data from the Quetico-Superior show large variation between types of visitors. Resort guests fished the most and were disappointed most often; paddling canoeists fished least and seldom complained.)

\* Copies available.



Lucas, Robert C.

A NEW RESEARCH PROGRAM FOR THE BOUNDARY WATERS CANOE AREA. Naturalist 16(4): 8, 10, 11, 14, 15, illus.

(The North Central Forest Experiment Station is planning a substantially enlarged program of research on the problems of the Boundary Waters Canoe Area, Superior National Forest. The program will include ecological research on the wilderness resource and also studies of the users of the area.)

R-414\*

Lucas, Robert C.

USER CONCEPTS OF WILDERNESS AND THEIR IMPLICATIONS FOR RESOURCE MANAGEMENT. In New Horizons for Resources Research: Issues and Methodology, pp. 29-39, Univ. Colo. Press. Also Naturalist (under title of Wilderness--User Concepts) 15(4): 22-29, illus., 1964.

(Historical shifts in wilderness definitions are large, and not necessarily ended. Wilderness policy needs to consider users' concepts of wilderness. Greater diversity and the addition of semi-wilderness management categories are suggested.)

RN-LS-68\*

Lucas, Robert C., and Schweitzer, Dennis L.

OUTDOOR RECREATION SURVEYS: LENGTH-OF-STAY BIAS AND ITS CORRECTION BY COMPUTER. U.S. Forest Res. Note LS-68, 2 pp. Lake States Forest Expt. Sta., St. Paul, Minn.

(In the typical, on-site recreation survey, the probability of a person or group being sampled is a function of their length-of-stay. A computer program which will weight a sample to give unbiased estimates of visitor data is now available.)

R-401\*

Stearns, Forest W., and Creed, William A.

WILDLIFE HABITAT AND THE MANAGED FOREST. Wis. Acad. Sci., Arts and Letters Trans. (1964) 53(a): 123-129. (Published in 1964)

(Discusses the changes in the intensity of forest management and compares the effects of past, present, and future silvicultural techniques on wildlife populations. Intensive forestry and game management can coexist provided that land management plans are coordinated for both uses. The outlook for the wildlife resource appears brighter with than without intensive forestry.)

\* Copies available.